ARMY R,D&A

- RESEARCH
- DEVELOPMENT
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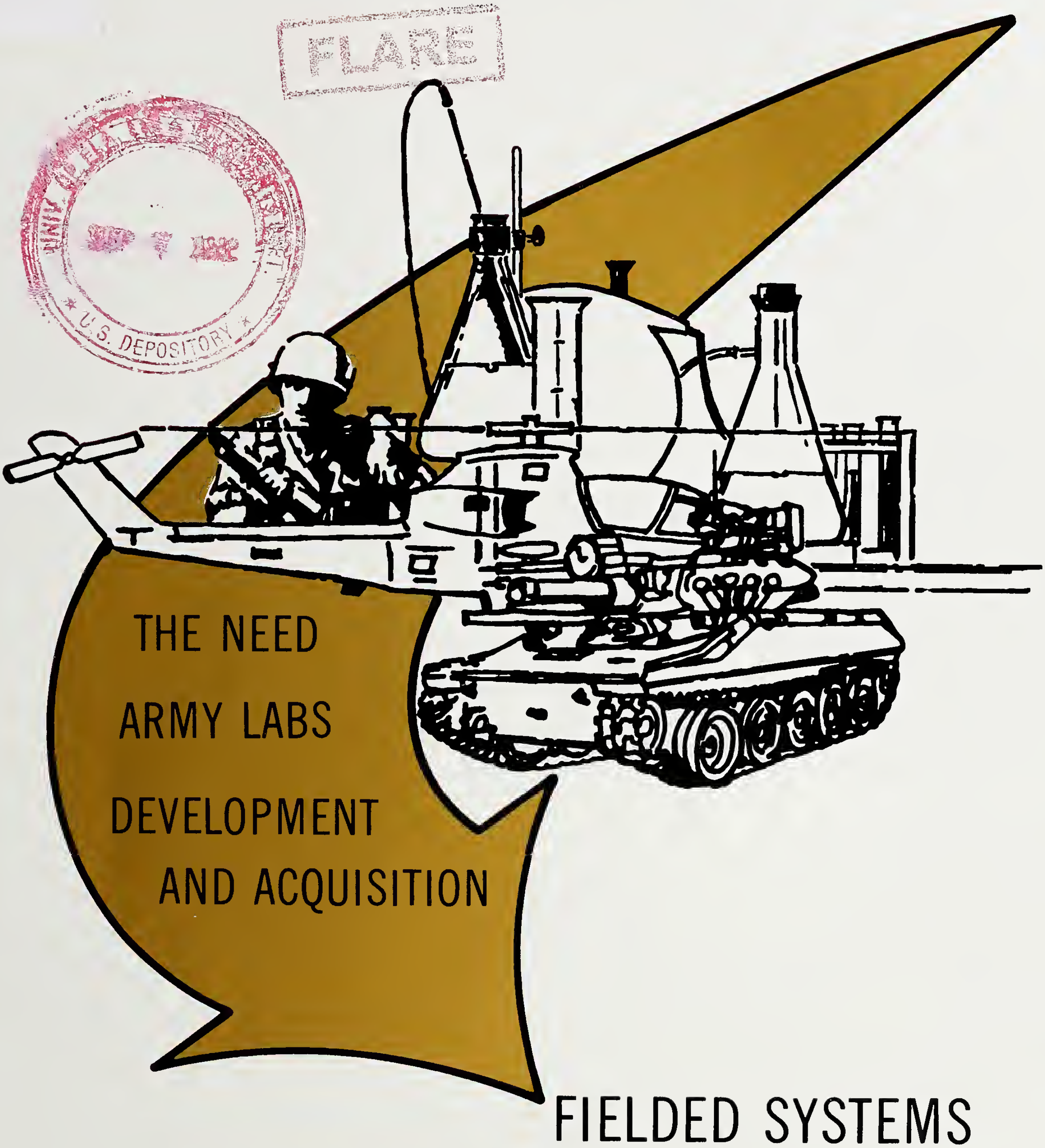
JULY - AUGUST 1982



THE ROLE OF ARMY LABS IN RDA

ARMY R,D&A

Vol. 23 No. 4 **JULY-AUGUST 1982**

OFFICIAL MAGAZINE OF THE RDA COMMUNITY, established 1959

ABOUT THE COVER:

Displayed on the front cover is an artist's drawing symbolizing the essential role played by U.S. Army laboratories in the evolutionary cycle leading to the fielding of the numerous items in the Army's inventory. Shown on the back cover are the seals and plaques of the major Department of the Army organizations represented in this laboratory issue.

FEATURES

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Distribution on an individual basis is restricted to active and reserve officers who hold a specialty indicator of R&D (51), Procurement (97), Atomic Energy (52) and Project Management (6-T).

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(USPS-584-330)

Army R, D&A Magazine (ISSN 06162-7082) is an official Army periodical published bimonthly by the Development, Engineering and Acquisition Directorate (DRCDE), HQ U.S. Army Materiel Development and Readiness Command (DARCOM), Alexandria, VA 22333, under sponsorship of the Assistant Secretary of the Army (Research, Development & Acquisition); the Deputy Chief of Staff for Research, Development and Acquisition, Department of the Army; and the Commander, DARCOM.

Second class official mail postage paid by the United States Army at Alexandria, VA. Postmaster: Send address changes to Editor, *Army R, D&A* Magazine, HQ DARCOM, 5001 Eisenhower Ave., Alexandria VA 22333. Use of funds for printing of this publication has been approved by Department of Army, 23 Feb. 1979, in accordance with provisions of AR 310-1.

Purpose: To improve informal communication among all segments of the Army scientific community and other government R, D&A agencies; to further understanding of Army R, D&A progress, problem areas and program planning, to stimulate more closely integrated and coordinated effort among Army R, D&A activities; to express views of leaders, as pertinent to their responsibilities, and to keep personnel informed on matters germane to their welfare and pride of service.

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Submission of Material: All articles submitted for publication must be channeled through the technical liaison or Public Affairs Officer at installation or command level.

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DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, D.C. 20310

This is an especially important issue because it is to be devoted exclusively to the Army laboratories as they exist today. The need for the laboratories is beyond question, and it is our responsibility to ensure that they are healthy and performing the roles required for the Army of today and of the future.

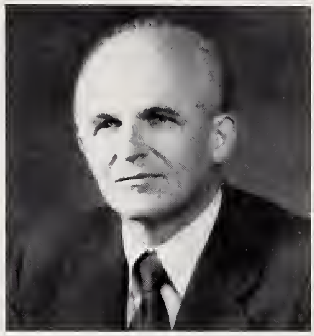
Of course, there is always room for improvement. That has been recognized by every Review. The challenge today is to find innovative ways to carry out the recommendations of such groups. Assisting me in conducting such reviews is Dr. Gordon Prather, my Deputy for Science and Technology. He is also an executive agent with respect to activities of the Army Science Board and of a new National Research Council Board on Army Science and Technology, both of which advise us on RDA issues.

This issue also contains overviews of the Army Staff functions concerning laboratory operations and programs, as well as articles about each field laboratory activity. The centerfold has pictures of individuals responsible for laboratory programs at each organization. The Army Materiel Development and Readiness Command (DARCOM), as the largest and most complex organization, also presents a brief overview of its headquarters management of laboratory operations and programs.

The past contributions made by our laboratories and the significance of their efforts challenges each of us to contribute more.

J R Sculley
J. R. Sculley
Assistant Secretary of the Army
(Research, Development and Acquisition)

Army Laboratories—
A Deepening Responsibility



By Dr. Marvin E. Lasser
Director of Army Research, ODCSRDA

These are exciting times! Never before have science and technology offered us so much while at the same time challenging us so strongly with their consequences. In many ways we are now at a new threshold. As we strive for greater science and technology achievements, we face overwhelming evidence that we must give more emphasis to greater organization and use of the potentials of what we learn. Better means can lead to better choices. The result can be profound in terms of the nation's economic, societal, and defense posture.

The Army laboratory community, perhaps more than most other groups, must address this challenge on an everyday basis. In cooperation and collaboration with their sister defense laboratories and with their colleagues in the academic and industrial sectors, the laboratories must span the gap from forces harbored in infintesimal subatomic systems to the inherent technical requirements of military applications.

Correctly, the public's expectations for national security are high, and nowhere more evident than in the materiel and supporting technology essential to our combat capabilities. Clearly, as a consequence, we have come to need no lesser scientific and technological skill and insight to ensure effective operational systems than were required to create the underlying technology in the first place.

Our people in the laboratories—and yes, those in DA headquarters too—must keep a long term view as they strive to resolve what often may seem to be short term issues. When major weapons systems and subsystems remain near the core of our fielded materiel for 20-40 years the difficulty of this problem is magnified many times.

We must have viable ways to keep the cutting edge on our investments, while at the same time staying out of the way of the blade. We must have available technology for "on-the-double" situations while we conduct our affairs in a reasonably orderly manner consistent with our ability to pay for the accelerating need for science and technology.

Accordingly, we must maintain support of our technology base through thick and thin times to the very best of our ability. However, we must also work steadily to ensure that this massive effort is simultaneously integrated into the enormously complex art of bringing weapons concepts to full scale production and sustaining them in the operational forces.

To achieve the best hardware at the right price we have to have people who can find an effective balance between available technology and how we do business. This is a tough problem in a world of intense technical competition and expanding military needs. We need people who will achieve new directions in research and exploratory development.

We need people who will stick with intricate technologies basic to military performance to systematically improve the specific state-of-the-art. We need people who can handle the persistent problems of production and operation. We need a host of people, from single-minded specialists to those who are especially competent to work, literally, "in-the-middle" to achieve responsive teamwork between the producers and consumers of science and technology.

Only by bringing and holding together good minds can we ever achieve the outstanding science and technology essential to the Army's mission. This is a basic reason for the existence of the Army laboratories. Their people help to ensure achievement of fundamental scientific and technological contributions to national security and to the nation as a whole. Whether in peace or war, these laboratories are truly indispensable to the country's strength and to science and technology itself.

Leadership of these laboratories is a great responsibility, one which is shared among many exceptional people. This responsibility has several notable aspects. One is to generate and make significant knowledge available as the nation needs it. Another is to ensure that the net flow and benefit serves the nation effectively. A third is to provide a reasonable environment for the free play of creative minds and an atmosphere that they find stimulating to the achievement of the Army's interests.

When we put it all together the demands are severe: broad but specific purpose, real intellectual and organizational freedom, proximity to challenging problems and talented people, provision of adequate facilities and equipment, and the existence of a structure which can and will make good use of the output of the laboratories.

This is much more than a mere matter of management. Efficient operation is important but human talent is the heart of the matter. The quantity and quality of contributions of the Army laboratories have frequently been exceptional; the rightness of their positioning increases the continuing challenge of performance.

Laboratory and Technology Management at the Army Staff

PHOTO
NOT
AVAILABLE

Mr. James E. Spates
Assistant Director of Army Research (Lab Activities)

Dr. Robert J. Heaston
Technology Manager, Weapon System Directorate, ODCSRDA

Dr. Henry J. Smith
Technology Manager, Combat Support Systems Directorate

Understanding the Labs

Understanding the Army in-house laboratories is a high priority item. From this understanding can come management change which will assist the laboratories in meeting their vital roles. The current atmosphere of reduced direct U.S. involvement in military conflicts offers an opportunity to introduce improvements into the laboratories with minimum disruption of critical activities.

The high stakes involved in our competition with the Soviet Union make it essential that increased attention be given to: better ensuring the relevance of the work the laboratories perform, improving facilities and equipment, improving the quality of technical leadership and staff in these laboratories, and providing these people the authority and flexibility to effectively manage their resources.

There are 34 formally recognized Army in-house laboratories, some large, some small, performing work in the physical, life, and personnel sciences in support of military and civil works programs of the Department of Defense. They constitute a large investment of dollars and manpower.

The acquisition cost of the laboratories' real property and equipment exceeds $1.5 billion. Nearly 20,000 people conduct the diverse activities of the laboratories. An annual cash flow greater than $2.3 billion is involved, with half of that being research and development.

About half of the R&D funds are retained by the laboratories to conduct work directly with their personnel; the other half being contracted largely to industry and universities. The balance of these funds are predominantly procurement monies that are used to achieve first acquisition of materiel systems and associated procurement support activities.

Army in-house laboratories have become increasingly important to DOD RDTE and procurement programs, and recent emphasis in these areas increases the importance of their performance. As major participants in the technology base and the systems development and acquisition process, the laboratories must achieve equipment improvements which reduce the impact of projected manpower contraints; obtain lower equipment production, operation, and support costs; and direct substantial R&D effort toward the longer term technological deficiencies and opportunities. Here, attention must be paid to the vitalization of our technology base, the stimulation of prototyping, the use of mature U.S. and allied technology, and the reduction of intelligence asymmetry and "technological surprises" in the face of a determined and well-supported Soviet competition.

The Department of the Army operates its in-house laboratories through well-established command elements: U.S. Army Materiel Development and Readiness Command, Chief of Engineers, the Surgeon General, and the Deputy Chief of Staff for Personnel.

Headquarters, Department of the Army Staff overview for the aggregate laboratory community is provided by the Deputy Chief of Staff for Research, Development, and Acquisition (ODCSRDA) LTG James H. Merryman. This agency, as the HQDA RDA proponent for DARCOM, directly interfaces with DARCOM through its Directorates of Army Research, Combat Support Systems, and Weapons Systems on day-to-day technology concerns—with support from its Directorate of Materiel Plans and Programs, Systems Review and Analysis Office, International Office, and others.

The Office Chief of Engineers (COE) operates its laboratories under the cognizance of their R&D Office. This office oversees both "military" and "civil works" laboratory activities and serves as the COE/ODCSRDA agent.

The Assistant Surgeon General for R&D also serves as Commander, Medical R&D Command and is the Office of the Surgeon General/ODCSRDA agent.

The Office Deputy Chief of Staff for Personnel operates through its Research Studies and Analysis Office to coordinate and direct personnel technology programs. This office directly operates the Army Research Institute for Behavioral and Social Sciences and oversees the technology base program of DARCOM's Human Engineering Laboratory. This office also serves as the ODCSPER/ODCSRDA agent.

The exact manner with which program formulation and review takes place varies depending on the program category and the current situation. Overview of institutional factors similarly varies. These relationships are often complicated and require prompt action at the executive management level. Accordingly, the Army staff has designated, under the Director of Army Research, an Assistant Director of Army Research (Laboratory Activities) to be the principal point of focus for the formulation, coordination, and execution of policies, plans, and guidance concerning Army laboratories. This position is currently held by Mr. James E. Spates.

Army laboratory management involves several issues which in the end merge into a single issue—*how can the Army increase the effectiveness of its manpower and dollar expenditures for laboratories?* This is, of course, much too large an issue to be taken in one bite. This single issue, insofar as the laboratories are concerned, may be viewed as consisting of three segments—*image*, *operations*, and *long-term perspectives*. Each of these segments is equally important and they are not necessarily mutually exclusive.

The Army is actively developing approaches that will further improve management of its laboratories. These actions are in various stages of advancement, some established, some evolving. Included in these actions are two dom-

inant interrelated thrusts. The first is the creation of a perspective structure encompassing the elements critical to effective management by the Army of its laboratories. The second is the use of a participative RDA planning process and product to provide general and specific RDA direction to the laboratories through the next two decades and to provide a base against which their individual and collective needs and contributions can be "measured".

Analyses of the posture of the Army laboratories have shown a need for information and action in four areas: need, capability, performance, and planning.

By need is meant those aspects of laboratory functions which relate to the goals, problems, attitudes, and biases of the potential military user of the technological output of the laboratories, and, implicitly, their contractors.

Capability refers to those aspects of laboratory functions which relate to the present and evolving technical capabilities represented by the know-how of the laboratory staffs and the facilities and equipment available to support them—and corresponding capabilities in the university and industrial sectors.

Performance concerns those aspects of laboratory functions which relate to the work activities, resource utilization, and output of the laboratories as they perform their current program of work.

Finally, planning deals with those aspects of laboratory functions which represent the current statement of the present and future actions to be taken if the needs of the military user are to be fulfilled with the capabilities available or developable in the future.

It is important to understand that the Army laboratories operate in partnership with the Navy and Air Force laboratories, under the general overview of the Office of the Secretary of Defense, Office of the Under Secretary of Defense for Research and Engineering. Individual Service procedures and roles vary significantly but each Service has a viable structure for its purposes.

A major step forward was taken recently with the establishment of the DOD Laboratory Management Task Force, a standing body authorized by DOD directive. The membership is composed of OSD and Service representatives from headquarters and field levels.

Among the recent outputs of the task force is the *Statement of Goals and Objectives for Department of Defense Research and Development Laboratories.* This statement has been approved by the Deputy Secretary of Defense and presents action targets relevant to Army laboratories in general and for local action by each Army laboratory. Effective implementation is a challenge to the entire laboratory community. This statement appears in the inside back cover of this issue.

Materiel Technology Integration at DA Staff

One of the objectives of the 1974 HQDA reorganization was to more closely integrate the Army laboratory technology base effort with the development and procurement phases of the materiel acquisition process.

As a result there now exists at the Army Staff level, within the two other directorates of the Office of the Deputy Chief of Staff for Research, Development and Acquisition (ODCSRDA), two technology managers, each serving as an adviser to one of that agency's principal directors.

It is a major responsibility of the two technology managers to provide technology advice and assistance to his respective director on those programs that fall under that director's sphere of responsibility.

As a part of this, one primary management function of these managers is to assist the transition of a system from a laboratory technology demonstration into subsequent development. Additionally, with many current R&D programs destined for completion shortly, there is strong emphasis on defining successor systems. Consequently, the technology manager at DCSRDA focuses much of his effort on the next generation of systems. This involves providing the needed justification for single program element funding (6.2) and advanced development (6.3A) technology demonstrations, supporting new Army thrusts, and participating on the core team of the DA/DARCOM/TRADOC laboratory reviews.

Currently serving as technology manager for the Weapon System Directorate of ODCSRDA is Dr. Robert J. Heaston, while Dr. Henry J. Smith is the technology manager for the Combat Support Systems Directorate.

Through these technology managers then, there is the assurance that at the Army Staff level there is a voice on the development side of the house assuring that the products of the laboratories are considered, properly oriented, and utilized.

Underlying these efforts are the activities of others in the ODCSRDA. Most prominent are Dr. Frank D. Verderame, assistant director (Research) and Dr. Charles H. Church, assistant director (Technology) in the Directorate of Army Research. They play a large part in linking the laboratory programs with threat assessments, technological opportunities, and long range materiel requirements.

The improvement over the past decade of Army-wide management and integration of its laboratory effort, the improved guidance of its technology base program, and the timely incorporation of this technology must give all who have been associated with those efforts a sense of pride of accomplishment. The years ahead then, should see an ever improving Army, reaping a fine product harvest from a responsive laboratory system.

AORS XXI Will Address Airland Battle 2000 Concept

The annual Army Operations Research Symposium (AORS XXI) will be held 5-7 October 1982 at the U.S. Army Logistics Management Center, Fort Lee, VA. About 200 Army, academic, and industrial leaders are expected to participate in the event which will be sponsored by the U.S. Army Training and Doctrine Command.

The theme of this year's symposium is "Analysis in Support of the Airland Battle 2000 Concept." A call has been issued for papers which pertain to the theme and other significant applications of operations research/systems analysis techniques to the solution of Army problems. Selected papers and presentations will be published in the proceedings.

The U.S. Army Combined Arms Combat Development Activity (CACDA), directed by MG Theodore G. Jenes, has overall responsibility for planning and conducting AORS XXI. For the ninth consecutive year, the U.S. Army Quartermaster Center and Fort Lee, and the U.S. Army Logistics Management Center will serve as hosts.

AORS XXI attendance will be limited to invited observers and participants. Symposium inquiries should be submitted to: Director, Combined Arms Studies and Analysis Activity, ATTN: ATZL-CAC-A (AORS XXI), Fort Leavenworth, Kansas 66027. Phone inquiries should be made to Mr. Leonard L. Friesz, AUTOVON 684-5488.

DARCOM Laboratories

By Dr. Richard L. Haley
DARCOM Assistant Deputy for Science & Technology

Since both DARCOM Commander GEN Donald R. Keith, and his Deputy for Research Development and Acquisition LTG Robert J. Lunn have had previous assignments as DCSRDA and assistant DCSRDA, their understanding and support for the laboratory system in the RD&A process is exceptional. They also emphasize the necessity for improvements in quality and productivity and insist that system project managers take advantage of in-house expertise when available.

Specifically assigned the staff responsibilities for laboratory and R&D program management are myself as assistant deputy for Science and Technology, MG Orlando E. Gonzales, director for Development, Engineering and Acquisition, Mr. James A. Bender, director for Technology Planning and Management, Mr. Seymour Lorber, director for Product Assurance and Testing, and Mr. Fred J. Michel, director for Manufacturing Technology. The four latter directorates have been expanding to nearly authorized strength during the past few months to meet the challenge of their new assignments, under the 1982 HQ DARCOM realignment.

Besides providing principal weapon system managers for all systems under development until transferred to other staff managers, MG Gonzales' organization manages the RDT&E program/budget procedures, international R&D activities, and the foreign scientific and technical intelligence and threat system.

MG Gonzales' responsibilities cover the entire intelligence spectrum for interaction of local foreign intelligence offices throughout the command where laboratory scientists and engineers may initiate intelligence production requirements which are then levied on DARCOM's two scientific and technical intelligence production agencies, the Foreign Science and Technology Center (FSTC) at Charlottesville, VA, and the Missile Intelligence Agency (MIA) at Redstone Arsenal, AL.

These agencies provide all-source, worldwide scientific and technical intelligence, including threats to the security of U.S. Army ground forces, technology and equipment improvements that could benefit U.S. R&D programs, and deficiencies in foreign materiel developments. FSTC also has two overseas collection teams in Europe and the Far East which are in a position to assist traveling DARCOM laboratory personnel in areas of their specific interests.

The Directorate for Technology Planning and Management, under Mr. Bender, supports the assistant deputy for Science and Technology in functions concerning scientific and engineering personnel management, including recruiting of senior executive service positions through the Army, management of the technology base, laboratory resources and evaluations, consolidation and publication of RD&A long-range planning documents, technical and industrial liaison, scientific and technical information, and military contractors' independent R&D programs.

In the tri-service arena, a recent initiative has been undertaken by the directors of laboratories of the other Services and myself. As the Joint Directors of Laboratories, we are chartered by the Joint Logistics commanders to optimize the efficient utilization of technology base and laboratory resources. Consequently, there will be greater program coordination between the Services.

During the past several years, a "Board of Technical Directors" has been organized and utilized by the assistant deputy for Science and Technology as a means of direct communication and discussion of problem areas, development and better understanding of the technology base program priorities, and participation in evaluations of laboratory performance.

The original 11 board members were the technical directors of the eight field commands with R&D responsibilities plus the directors of the Army Materials and Mechanics Research Center, the Human Engineering Laboratory, and the Army Research Office. Added shortly thereafter were the director of the Army Materiel Systems Analysis Activity and the technical director of the Test and Evaluation Command.

I recently invited the deputy directors of FSTC and MIA to participate in the meetings because of increased recognition of the relationship of intelligence and laboratory programs. In addition, laboratory directors and associate technical directors of commands are invited to attend an annual meeting.

All of the Army DARCOM R&D laboratories, along with the other Army R&D laboratories, are described in this special issue of *Army RDA Magazine*. They represent a wide span of RDT&E activities which support every aspect of Army materiel and the individual soldier. Today's Army can be proud of its research and technological sophistication and of the practical application of this expertise in support of Army needs.

ARRADCOM Labs Fulfill Diverse Army Materiel Requirements

Just as brushes and tubes of paint are primary needs of an artist, so are cannons, machineguns, rifles, and their ammunition, essential needs of an army. Each has other vital needs but these examples normally typify the respective trades. For the U.S. Army, the job of researching, developing, and then initially procuring these example weapons and munitions, along with others, is the responsibility of the U.S. Army Armament R&D Command, and the starting point for all of this is the productive laboratory structure of this command.

The four primary lab elements in the command are the Large Caliber Weapon Systems Laboratory, Fire Control and Small Caliber Weapon Systems Laboratory, Chemical Systems Laboratory, and the Ballistic Research Laboratory. The Small Caliber and Large Caliber Labs are located at ARRADCOM HQ, Dover, NJ, while the Chemical and Ballistic Labs are at Aberdeen Proving Ground, MD.

Large Caliber Weapon Systems Laboratory

Tomorrow's Army must be able to meet the demands of a major confrontation, potential small wars, or brushfires. Future battlefields will require increased ability to fight high-intensity assaults, to carry out effective operations in urbanized terrain, and to rapidly deploy both men and materiel. The battlefield will also be more fluid, requiring better use of the land, more positive identification of targets, and engagements at longer ranges than possible with current weapons.

Due to rapid advances in counterweapon designs, new, affordable weapon systems are necessary, and Soviet numerical advantages necessitate a reduction in the number of our rounds necessary to disable armored fighting vehicles, aircraft, and personnel.

The Large Caliber Lab supports major developing commands and project managers as well as readiness commands in improving fielded systems. The lab is responsible for RD&E of "smart" munitions, enhanced artillery systems, mines and demolitions, cannons for tanks, and life-cycle engineering for all Army munitions, including nuclear rounds. Its activities range from basic research in the fundamental sciences to development and quality control engineering.

Established in January 1977, the Large Caliber Lab is a principal R&D element of ARRADCOM, at Dover, NJ, with a major sub-element at Watervliet, NY. Its 1,740 personnel include 1,050 scientists and engineers.

XM833 Armor-Piercing Round

Utilizing an aggressive exploratory R&D approach, the laboratory is pursuing a number of interesting technical areas. Novel artillery concepts include Copperhead II, a 155mm, autonomous projectile that provides a one-shot kill capability against armor targets. There is the Anti-Radiation Projectile, which will defeat enemy radar units, and the Artillery Registration and Adjustment System, which provides a single-shot registration capability.

Another potentially high pay-off area is the improved sensing munitions program. This program offers true fire-and-forget projectiles, and a common family of cost effective, unguided munitions with increased lethality against massed targets in defilade, greater indirect fire, anti-armor and counter-battery kill capability, and an all-weather system.

The concept of attacking hard targets from above, or top attack, is coming into reality through a project called the Smart Target Activated Fire-and-Forget (STAFF). In a direct fire role, the spinning projectile flies over the target, and as it passes its sensor "sees" the target and initiates a self-forging fragment warhead downward to defeat the vehicle. STAFF is a candidate in the Rattler Program.

Tank firepower improvements are typified by a kinetic energy, armor-piercing XM833 round, and a chemical energy XM815 round with armor defeat and anti-materiel capability.

In the area of lightweight, more effective infantry armament devices, the lab is developing two 81mm expendable assault weapon systems for urban use. The Lightweight Recoilless Gun and the Minimum Signature Envelope Recoilless Gun provide low signature weapons with a new capability for defeating buildings, bunkers, and light-armored vehicles.

Other areas of the lab's mission include improving the safety, efficiency, and logistics burden of the combat engineer and explosive ordnance demolition (EOD) technician, and to insure the latter's capability the laboratory is developing improved demolitions, several mine systems, and EOD tools.

Furthermore, the Large Caliber Lab is DARCOM's lead laboratory for energetic materials technology in support of munitions development, pollution abatement, explosives detection, identification and producibility, hazards analysis, plant design, and accident investigations. It plays a major coordination role among the Services and other federal agencies, and among the U.S. and its allies.

From its efforts here will come safer or more powerful explosives for use in advanced warheads and propulsion systems, and cheaper, more abundant ingredients that may be drawn from the civil economy to meet wartime requirements.

The Large Caliber Lab is also a leader in the field of manufacturing technology. Ongoing work includes the Rotary Forge System, the controlled-cooling process for TNT loading of projectiles, and computer-aided manufacturing and assembly of mines and fuzes.

Other activities are engineering support for a quick-reaction site defense missile, a more lethal surface-to-surface missile, an advanced charge design for tank ammunition, and techniques to reduce wear and erosion.

In the weapons technology arena, lab goals are improved cannon systems, greater muzzle energy, increased firing rates, and better accuracy. Examples of current work include improved tank turrets, control of barrel temperature, a new multi-lug breech, and upgraded barrel construction.

Aware that future munitions and weapon systems will require advanced fuzing technology in the areas of air defense, automated artillery, and anti-armor, the lab is developing fuzing for antiarmor/helicopter tank ammunition and air defense projectiles, a cost effec-

tive and safe arming device, along with next-generation artillery.

Due to the efforts of the Large Caliber Lab, there has been a considerable reduction in the cost as well as an improvement in quality of training ammunition, allowing additionally, increased safety in training exercises and reduced range space.

Looking well into the future, the Large Caliber Lab is influencing the Army's support of the combat soldier into the 1990's and beyond by such additional programs as:

- SADARM, an artillery fire-and-forget concept for defeating massed targets. Launched over the target area, the SADARM's submunition descends on a parachute, its sensor is activated, and the beam sweeps the ground. Targets within the beam are detected, initiating a long-standoff warhead which projects a slug toward the target, perforating its top armor.
- The Army's first new mortar system in 25 years—the 60mm Lightweight Company Mortar System M224—was fielded in 1981 with a multi-option fuzed HE cartridge for indirect fire support.
- The Medium Caliber Antiarmor Automatic Cannon Program resulted in the Army's first medium caliber, automatic, antitank cannon. A primary candidate for the armament system on future light-armored vehicles, this weapon employs compact, telescoped ammunition and a rotating chamber-autoloader system.

The FY 82 program in the Large Caliber Weapon Systems Lab is projected to be in excess of $200 million; $120 million for RDT&E, $78 million for procurement, and over $5 million for the OMA program.

Fire Control & Small Caliber Weapon Systems Laboratory

The Fire Control and Small Caliber Weapon Systems Laboratory is responsible for all armament systems in calibers up to 40mm and for all Army gun system fire control regardless of caliber. The laboratory also supports a wide variety of major weapon system developments such as short range air defense, infantry fighting vehicles, helicopters, artillery, tanks and various infantry systems.

Formed in 1977, the FC&SCWSL has a staff of 590 personnel of which 345 are scientists and engineers.

It is laboratory policy that emphasis be placed on accelerating the transitioning or user priority items; providing increased attention to integrated logistic support, emphasizing timely and quality deliverables; and building upon meaningful research/technology base programs. This policy supports the R&D goals of the laboratory, which are:

- Initiate, develop, and present technically sound proposals to fill the recognized new materiel needs of the U.S. Army strategic and tactical forces.
- Anticipate unrecognized needs of the combat arms and to initiate and develop proposals to fulfill those needs.
- Maximize the performance capabilities of developmental equipment and minimize the elapsed time of the development cycle.
- Improve the quality of the technical guidance and review applied to project managers and other commands and programs covering the complete technical life cycle.

The mission of the Fire Control and Small Caliber Weapon Systems Laboratory encompasses three major areas of responsibility:

- Establish and maintain a scientific and technical community that includes government, industry, and university personnel for the purpose of advancing weapon technology responsive to the needs and tactics of the user and to avoid technological surprise.
- Develop new items and product improvements for fielded items and ensure their effective transition into quantity production.
- Provide technical assistance and actions through the Army's readiness agencies.

These areas of responsibility cover a broad spectrum of the Army's R&D program, which encompasses fundamental and applied research in physics, chemistry, applied mathematics, metallurgy, materials science, the engineering disciplines, control theory, optimization theory, systems analysis, and modeling.

The FC&SCWSL is organized into six divisions. Although each division is concerned with specific areas of the laboratory's mission, the R&D teams within each of the divisions have been flexibly organized in order to permit allocation of personnel to multidisciplinary projects; this capability is indispensable to continued small caliber ammunition and fire control development.

The laboratory's Exploratory R&D Program is currently pursuing a number of technical areas of research in fire control. This program includes development of a 6.1 technology base in electromagnetic propagation and processing; innovative techniques for target location, identification and tracking; control theory; linear and nonlinear systems analysis; and data sensor/computer interfacing for fire control components/subsystems/systems for Army weapon systems.

In the area of armament and materials, research is being conducted which addresses high-rate mechanisms to describe and predict the effect of multiple, intermittent physical excitations on weapon performance and reliability and research in munitions effectiveness for providing improved weapon accuracy and reliability, propulsion, and materials processing.

This laboratory's exploratory development program is divided into seven technical areas. The first four technical areas develop system-oriented concepts, while the last three emphasize the generic technologies in support of the laboratory's mission.

The objective is to develop and maintain a technology base upon which advanced development of fire control for all gun systems, future automatic cannons, future small arms for all the Services, improved small caliber munitions, and innovative material applications for gun systems can improve existing systems and/or to develop new systems.

Current emphasis includes improving

DOVER DEVIL—General Purpose Heavy Machinegun

infantry effectiveness through the Joint Services Small Arms Program projects, and improving the Infantry Fighting Vehicle armament, lightweight armament for rapid deployment capability, lightweight air defense gun systems, all-weather fire control, helicopter armament, and tank fire control to provide improved hit probability. The approach is an integrated program of analysis, experimentation, and test demonstration that advances the state-of-the-art and leads to concept validation.

Some of this laboratory's accomplishments since its inception are:

• The Squad Automatic Weapon (SAW), a one-man portable, 5.56mm lightweight machinegun intended to replace the M16A1-AR in the automatic fire role. Designated the M249 and developed by Fabrique Nationale of Belgium, it was selected from among four candidates. Ammunition for this weapon also resulted from a NATO competitive evaluation. The weapon has greater versatility in that it can be fed from either a 200-round ammunition canister or from the standard 30-round M16A1 magazine. It has a sustained fire rate which is six times that of the M16A1.

• Computer Ballistic Mortar M23 (MFCC) is a lightweight, handheld digital calculator that provides fully automated fire direction, computation, communications and display capabilities for the 60mm (Lightweight Company Mortar), 81mm and 107mm (4.2-inch) mortar systems. This unit accepts and processes data for selected ballistic trajectories in indirect mortar fire missions. Computations of complex parameters can be handled with a degree of accuracy previously only possible with a large fixed computer system.

The M23 MFCC may be used in conjunction with the Digital Message Device which accepts incoming messages directly from a Forward Observer or the Fire Direction Center, display each on command, and perform all required computations for firing from multiple positions.

• The General Purpose Heavy Machinegun (Dover Devil) is an in-house developed, cost effective, fully automatic machinegun with multi-purpose applications, including infantry, armor and aircraft armament. Designed to replace the M2, .50 caliber machinegun which entered the active inventory in 1933, it will permit the optional field conversion from caliber .50 to 20mm by rapid modular component interchange.

This new weapon, in .50 caliber, is 35 pounds lighter, has less than half the parts and will cost one third less in production than the M2.

• The Submachine Gun, M231, (Firing Port Weapon), an automatic direct fire weapon, ball mounted within the Infantry Fighting Vehicle squad compartment, two on each side and two at the rear. This weapon, which supplements the M2 IFV main armament, is magazine fed and fired from an open bolt.

• Automatic Target Cueing (AUTO-Q) is a state-of-the-art system to improve the target acquisition capability of the helicopter crew by automatic location and identification of targets in on-board sensors, such as Forward Loading Infrared (FLIR) or TV, followed by audible warning of their presence, and by visual cues to mark their location and identity. The cueing system will process remote sensor output signals over the entire field of view and is designed to be mounted in a variety of helicopters for tactical use.

• The Mast Mounted Sight (MMS) is a fire control concept that will significantly increase aircraft survivability by permitting scout and attack helicopters to detect, recognize and engage targets while in defilade.

Chemical Systems Lab

The principal mission of the Chemical Systems Laboratory is to develop equipment and material for U.S. military forces for use in a type of warfare that has not been fought by American troops since World War I. Major R&D emphasis is on protecting the soldier from chemical agents, detecting and identifying agents if they are employed in the field, decontaminating the soldier if he becomes contaminated, and developing chemical binary munitions.

From the high caliber of talent in this lab will come for example, future CB protective masks that will take advantage of advances in materials science. Threat and laser weapons will be countered with optical coatings and light adaptive lens materials. New materials also hold out the possibility of providing some shrapnel protection for the eyes and face.

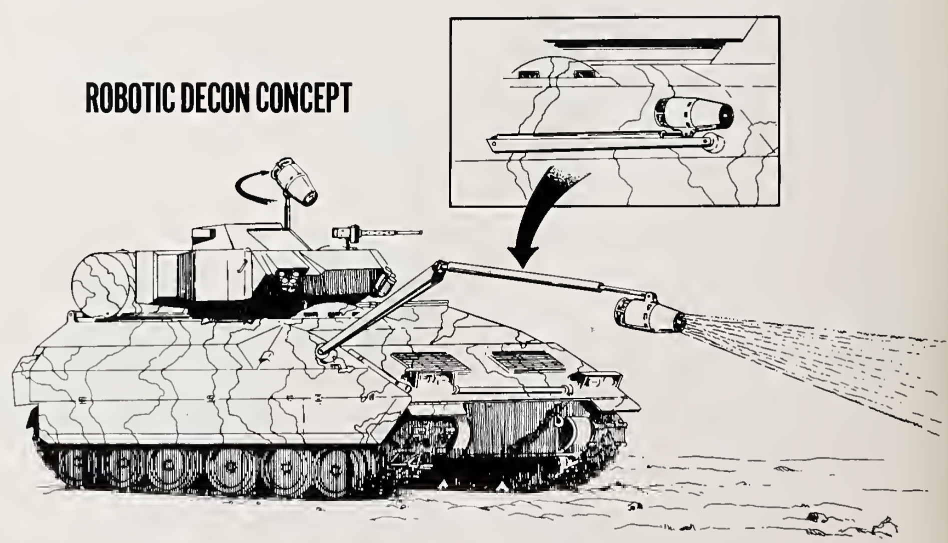
Tomorrow's chemical protective overgarment will permit a freer flow of air and thereby lessen the heat burden associated with today's overgarments. A 40 percent reduction in heat load has already been demonstrated with a fabric now in development.

Biotechnology now offers important opportunities for CB defense. For example, a CSL-university effort has produced antibodies to threat agents, and these antibodies have been used to demonstrate an increase in detection sensitivity. This system may tell us what agent has been used, with little or no false alarms.

Additionally, a university scientist in an Army-sponsored program discovered that a certain sea creature produces minute quantities of an enzyme that "eats" an enemy agent, a discovery that offers a potential for surface, skin, and overgarment barriers.

Micro-processors are being applied to developmental CB detectors, permitting the quick change of detector logic to adapt to new agent threats. False alarms should also be reduced with test-proofed software selection.

Detecting CB agents before they reach unprotected troops is the aim of workers using electro-optical techniques. Passive remote detection of chemical vapors has been demonstrated using absorption of terrain generated infrared energy, while



DECON Vehicle showing Robotic Arm concept

active remote detection has been achieved using a laser source and a Differential Absorption Lidar system.

VISTA, or very intelligent surveillance and target acquisition technology, is a large area. An example is the NBC reconnaissance system for vehicles. This standard vehicle will first use point NBC detectors and later, remote NBC detectors, and will be able to plot the map coordinates of NBC contamination as well as identify these agents.

Command, control, communications and intelligence advances by others in DARCOM and DOD will permit accurate and rapid forecast of downwind hazards using recon vehicle generated agent, weather, and location data.

Ion mobility spectroscopy (IMS) is a technology built from the ground up by a CSL researcher and his United Kingdom counterpart. The sensitivity and response time of a UK application of IMS, are exploited in a chemical contamination monitor, a handheld device to quickly determine if a soldier or his equipment is contaminated.

Robotic technology holds the promise to eliminate the time-consuming, people-intensive, and dangerous task of vehicle decontamination. One example is the concept for a forward decon vehicle using a robotic arm and hot air NBS decon device.

Facilities for achieving this progress have been in the Edgewood area of MD since 1918. Although the mission of chemical development and readiness has remained the same, the designation has changed many times. In 1977, CSL assumed the research, development and engineering functions of Edgewood Arsenal, continuing the Army mission of chemical development and readiness as a major research activity of ARRADCOM.

More than 1,000 civilian employees and 90 military personnel are assigned. In addition, 300 civilian employees and 3 military personnel are assigned to ARRADCOM support elements in Edgewood.

In FY 82, CSL has an operating fund totaling $133.8 million, including the prior year carryover, earmarked for the R&D mission, operating and maintenance, and procurement. CSL officials anticipate the CSL budget will increase in FY 83 with the growing emphasis on training and providing U.S. military forces with equipment to defend themselves in a chemical warfare environment.

Ballistic Research Lab

ARRADCOM's Ballistic Research

VULNERABILITY/LETHALITY research at BRL plays a key role in increasing the survivability of major Army systems such as the Advanced Attack Helicopter (shown above), the Black Hawk, and the M1 tank.

Laboratory (BRL) plays a significant role in shaping concepts in armor and munitions technologies, ballistic missiles, and the electronic computer. In fact, a survey of the lab's activities reflects a broad scope of capabilities in the Army's materiel acquisition and readiness operations. BRL scientists and engineers provide ballistic data covering the entire range of weaponry; from small arms and their ammunition, through large missiles to nuclear weapons and their effects.

With a civilian workforce of 496 employees that include 367 scientists and engineers, 44 technicians and 85 administrative personnel, BRL is augmented with 8 military officers and 12 enlisted personnel. BRL's facilities include 70 acres in a technical compound near the APG headquarters and a test site on Spesutie Island. There are more than 13 barricaded positions which are used for live investigations into blast penetration or fragmentation effects and for carrying out other ballistic experiments.

BRL has research teams working in such highly specialized fields as aerodynamics of shell, transitional ballistics, transient muzzle flows, sabot discard, boundary layer effects, flow separations and interactive dynamics for non-rigid payloads. All are incorporated to enhance munition performance and to produce accurate firing tables and fire control data for the Army's land-based weapons.

As the lead laboratory for both ballistic technology and vulnerability technology, BRL develops methods and data for assessing the lethality of existing and developmental munitions and the vulnerability of many classes of military targets. Principal programs include surface targets such as armored vehicles, tube artillery, command communications and control equipment and air defense systems, as well as aerial targets, like helicopters and fixed wing aircraft.

Vulnerability/lethality research on military targets as well as vulnerability reduction studies have played key roles in increasing the survivability of major Army systems such as the Black Hawk, the Advanced Attack Helicopter, and the M1 tank.

While BRL's terminal ballistics personnel design and evaluate advanced technology prototype chemical and kinetic energy anti-armor devices and armors, they have also provided assistance to the Department of Transportation and the Military Traffic Management Command, to reduce the hazards of transporting fuels, chemicals and explosives and to improve safety practices for railroad operations.

Efforts of terminal ballistic researchers have also had an important influence on work conducted by the Defense Nuclear Agency and the Defense Explosive Safety Board relative to structural response to blast, shock and thermal loading.

BRL scientists who study the interior ballistic cycles of Army gun systems currently are directing considerable attention to the design of minimum launch-weight kinetic energy projectile sabots to enhance lethality of the Army's M1 tank cannon system.

Concurrent programs involve liquid propellants, low vulnerability and novel propellants for artillery, tank gun and air defense ammunition. Enhanced accuracy has been obtained for weapons fired from vibrating platforms with the precision aim technique, a computer regulated firing circuit.

Installation of a powerful new computer system named heterogeneous element processor (HEP) is scheduled for September of this year. Featuring a completely new architecture, this multiple instruction, multiple data stream design makes extensive use of parallel and pipeline techniques, and state-of-the-art componentry to provide a high-speed computing tool at moderate cost.

The HEP will consist of 4 main frames, expandable to 16, operating in parallel with global access to two million words, expandable to 128 million words, of 50 nanoseconds bipolar memory. Developed for BRL, but applicable to general scientific computing, the HEP will increase the large scale computing capability at BRL by 400 percent.

BRL has five teams, each specializing in a different area, and responsible for weapon system analysis and system en-

gineering. The air defense team is heavily involved in the evaluation of the Army's new DIVAD (Division Air Defense) gun system.

An artillery team is exploring enhanced effectiveness of field artillery, including participation in Human Engineering Laboratory Battalion Artillery Test (HELBAT) artillery system field experiments. An armor team is assessing emerging technologies of armored combat vehicles, such as the precision aim technique and applique armors as well as preparing a handbook on generic tank cannon capabilities; and an infantry weapons team has contributed to the development of improved infantry antitank weapons, such as its realistic battlefield environment system engineering analyses of the Smart Target-Activated Fire-and-Forget, Sense and Destroy Armor, and Guided Anti-Armor Mortar Projectile munitions.

The fifth team, smoke and obscurants, is planning and coordinating an Army program on multispectral screening agents, especially related to the millimeter wave realm.

BRL's recent contributions to provide the American soldier with superior weapon systems include M1 armor and continuing development of a technology base in armor in order to respond to future needs for new armor designs; kinetic energy penetrator, with investigations providing the basic information for the design of an armor defeating antitank round; antitank warheads for the TOW and Hellfire systems; and instrumented tank gun/sabot technology for improvement of first round hit probabilities.

In summary, the significant contributions that BRL has made to Army weapon system technology are a result of the time, talent and dedication expended by the lab to improve the Army's future fighting capability. This holds true, not only for BRL, but for the entire ARRADCOM laboratory structure.

The preceding article was prepared by key personnel at the U.S. Army Armament R&D Command.

ODCSRDA Approves SAW for Type Classification

The Office of the Army's Deputy Chief of Staff for Research, Development and Acquisition (ODCSRDA) has approved type classification of the Squad Automatic Weapon (SAW). This action reportedly represents a major achievement for the U.S. Army Armament R&D Command.

The 5.56mm SAW Machine Gun will be deployed primarily in infantry fire teams with the Army and U.S. Marine Corps. Its operational need has been recognized since the obsolescence of the 30-caliber Browning Automatic Rifle which resulted from the adoption of the 7.62mm M14 Rifle.

Unsuccessful attempts have been made to fill this operational void with an automatic fire version of the M14 followed by the 5.56mm M16A1 Rifle with bipod. Some units later adopted the practice of employing the 7.62mm M60 Machine Gun at the squad level, but soon recognized that the excessive weight of this weapon resulted in an unacceptable tradeoff with respect to maneuverability.

The SAW was developed under management direction of the SAW Project Officer within ARRADCOM's Fire Control and Small Caliber Weapon Systems Laboratory. It was supported by a Joint Service Operational Requirement (JSOR) endorsed by the Army, USMC, Air Force and Coast Guard.

The JSOR describes the need for a one-man portable, lightweight machine gun capable of providing effective suppressive fire to a range of 1,000 meters, commensurate with the projected threat. Based on extensive testing, the SAW demonstrated its capability of effectively satisfying this operational need.

The SAW system components, besides the M249 5.56 Machine Gun, included in the type classification action where the M855 5.56mm Ball Cartridge; the M865 5.56mm Tracer Cartridge; and the M27 5.56mm Metallic Belt Cartridge Link.

The M249 weapon evolved from a competitive evaluation of four candidate systems; the XM106, XM249, XM248, and XM262. The conventional piston-actuated gas system allows for a choice of two power settings, achieved by regulating the bleed of gas entering the cylinder. This feature provides for a constant 750 rounds per minute cyclic rate even under adverse firing conditions.

This 15.6 pound weapon fires from the open bolt position which reduces the likelihood of cook-off in an automatic gun required to operate with a hot barrel. The M249 has a quick change barrel capability which can be achieved within three seconds. It can be both belt fed from a 200-round container or the 30-round magazine used in the M16A1 Rifle.

The M855/856 cartridges used in SAW comply with the NATO 5.56mm Second Caliber Standardization Agreement (STANAG 4172). This STANAG was agreed upon with the NATO countries to assure commonality of ammunition. The SAW type classification puts the U.S. in a lead role with respect to implementation of the STANAG.

The M855 Ball Cartridge is similar in configuration to that of the M193 used in the M16A1, but offers significant improvements in extended range effectiveness. Likewise, the M856 Tracer Cartridge uses the same exterior cartridge envelope as the Army's current standard M196 Tracer, but extends the daylight-visible range by as much as 50 percent.

At the conclusion of the competitive evaluation, a special in-process review was held on 28 May 1980, recommending the XM249 weapon and XM855/856 ammunition for accelerated development to ready the system for FY 82 procurement.

The SAW Project Office devised and executed this program entailing system redesign, procurement, test and evaluation, and adherence to and compliance with all DA regulations prerequisite to a development in-process review.

The significance of this achievement is that ARRADCOM transitioned the program from validation to type-classification in 15 months, much less time than the normal two or three-year full-scale engineering development phase, said a SAW official, who added that this also resulted in considerable savings.

The remaining research, development, test and evaluation tasks include a continuation of the integrated logistics support program along with finishing development of supporting equipment. A blank firing attachment will be developed for training and integration with the Multiple Integrated Laser Engagement System, a training device.

Newly designed, load-carrying pouches have been extensively tested and technical data packages will be developed to support their type classification and procurement. These pouches, which have been designed to attach to the standard load-carrying belt, will provide the machine gunner with the capability of carrying 600 rounds of M855/856 ammunition during the assault. A weapons storage rack development program is being planned to assure the security of SAW weapons when fielded.

Procurement planning is well under way, said the official. The advanced procurement plan has been submitted to Department of Army headquarters and the FY 82/83 procurement scopes of work have been developed. The current 5-year (FY 82-86) procurement plan includes the purchase of approximately 26,000 SAW weapons for the Army and 9,000 for the U.S. Marine Corps. These quantities are expected to escalate once the non-infantry units and other joint services finalize their requirements.

AVRADCOM Labs Develop Technology for Air/Land Battle 2000

As we evolve to the Army of the 1990's and beyond, our doctrine will shift from the active defense to the Air/Land Battle and finally the Air/Land Battle 2000 concept of fighting. The Air/Land Battle 2000 and Army Science Board findings on equipping the Army of the 1990's dictate an increasing requirement for Army aviation.

The problem of an aging helicopter fleet and increasing technological obsolescence is further exacerbated by the new mission requirements placed on Army aviation by the future threat, the Air/Land Battle 2000 concept and the realization that we may be required to fight anywhere at anytime. The Army of the future will face superior numbers, a strong air defense and air-to-air and electronic warfare/nuclear-biological-chemical/laser threats.

The future battlefield will be characterized by a battle expanded into the airspace and depth of enemy formations, intense battle at the decisive point, and difficult command and control.

Close combat forces will operate in the enemy's rear operations. These forces will be dispersed, required to fight in any direction and to fight for protracted periods with minimal resupply. These battlefield characteristics increase demands on Army aviation. Air resupply and combat air assault are essential.

The future fleet must be numerically sufficient to the task and, therefore, affordable. Our reliance on strategic/critical materials must be reduced. The future fleet must be survivable, robust, battle damage tolerant, possess low signatures, and capable of all-weather/around-the-clock operation, able to function on the dirty/EW battlefield, fuel efficient, have extended range capability, provide platforms for target engagement, with direct and indirect fire, complement other systems, and provide standoff target acquisition and engagement.

The Army of the late 80s and beyond will be characterized by agility, deception, maneuver, and firepower, all of which require Army aviation and the application of advanced technology.

These are only a few of the future battlefield challenges for which the laboratories of the U.S. Army Aviation Research and Development Command (AVRADCOM) are developing technological opportunities and solutions.

A fundamental objective of the AVRADCOM laboratories is the demonstration of aviation technology needed to provide simple, rugged, reliable air mobility equipment of superior performance, lethality and survivability which the typical soldier can operate and maintain. Technology areas, disciplines and principal thrusts of the AVRADCOM laboratories are summarized in Figure 1.

TECHNOLOGY	DISCIPLINE	PRINCIPAL THRUSTS
AEROMECHANICS	Fluid mechanics; dynamics; flight control; acoustics	Develop and demonstrate low-weight advanced rotors, and flight control concepts; Improve mission effectiveness, survivability, safety, availability; and reduce cost.
PROPULSION	Aerothermodynamic components; controls and accessories; mechanical elements; thrust producers; materials; processing, infrared suppression.	Develop fuel efficient turboshaft engines for Army aircraft resulting in greater payload capacity and reduced cost of operation.
STRUCTURES	Design criteria; weight predicting materials; fatigue and fracture mechanics; structural design concepts; service evaluation and usage; non-destructive inspection/testing; fabrication technology.	Develop technology and demonstrate new composite components and primary structures to enhance safety, survivability, battle damage repair and reduce cost/weight.
AVIATION ELECTRONICS	Avionics systems; communications; navigation; tactical landing; air traffic management; environment sensing; instrumentation; surveillance; night vision systems integration; electronic warfare.	Integrate aviation electronics functions to reduce weight, cost, size, pilot workload and increase system reliability and effectiveness through digital avionic systems.
WEAPONIZATION	Guns; missiles and rockets; munitions; target acquisition/fire control.	Develop, demonstrate and integrate weapon systems to defeat multiple hard point targets at extended ranges under all battlefield conditions and to provide air-to-air self defense.
AVIATION SURVIVABILITY	Aircraft signature control; passive/active countermeasures; ballistic and laser vulnerability reduction; survivability/vulnerability analyses; crash survival; NBC protection/decontamination.	Develop passive and active CM for Radar, IR, and Laser Threats. Signature suppression technology to be coupled with warning and jamming development. Demonstrate state of the art in signature control with ALOA. Develop improvements in ballistic, crashworthiness, laser, and NBC protection for aircrews and aircraft systems. Upgrade combat effectiveness analysis.
MISSION SUPPORT	Cargo systems; ground support equipment; secondary power systems; landing gear systems; environmental control systems; life support equipment.	Develop cargo handling and ground support equipment to improve operational efficiency including battlefield reconstitution/resupply.
SYSTEMS INTEGRATION	R&D simulator; man-machine integration; comprehensive helicopter analysis; advanced system concepts; Night research systems simulators and demonstrators.	Develop rotorcraft systems integration simulator; develop a 2nd generation comprehensive helicopter analysis system to provide an integrated analysis capability to reduce risk and cost associated with developing systems; LHATDRPV alternate missions XV-15 and RSRA.

Fig. 1. Technology Areas, Disciplines, Thrusts

To accomplish their missions, the AVRADCOM laboratories have a total of 35 military and 818 civilian personnel. Thirty percent of the engineers and scientists have master's degrees and 9 percent have doctorate degrees. AVRADCOM laboratories consist of the Army Avionics Research and Development Activity (AVRADA), Fort Monmouth, NJ, and the Army Research and Technology Laboratories (RTL), NASA Ames Research Center, CA.

AVRADA conducts that portion of AVRADCOM's mission pertaining to avionics from applied research through production. This includes engineering, product assurance, human factors engineering, integrated command and control, positioning and navigation, communication, controls and displays, air traffic management and landing, and systems design and integration.

The RTL includes four laboratories: Applied Technology Laboratory, Aeromechanics Laboratory, Propulsion Laboratory, and Structures Laboratory. The Applied Technology Laboratory, located at Fort Eustis VA, conducts R&D efforts in the technical areas of aircraft weaponization, safety and survivability, reliability, and maintainability, mission support equipment, applied aeronautics, and structures and propulsion.

A unique feature of the RTL is the interagency relationship of three of its laboratories (Aeromechanics, Structures and Propulsion) with NASA at the Ames, Langley, and Lewis Research Centers, respectively. This feature not only conserves the resources of both agencies in the performance of research in areas of interest common to each, but

also provides the Army with direct access to the facilities and professional expertise of NASA for application to specific Army requirements. The AVRADCOM laboratory complex represents a special blending of both Army and NASA facilities which can be utilized to meet the R&D needs of the Army as well as the overall aviation community.

AVRADCOM laboratories work in concert with other DARCOM laboratories, industry, academia, and other government agencies. In FY 81, for example, AVRADCOM laboratories contracted industry and academia for approximately 56 percent of its tech base expenditures. The proportions of the tech base funding devoted to the technologies addressed by the AVRADCOM laboratories are illustrated in Figure 2.

Participation in numerous professional societies, the independent R&D program, and the rationalization, standardization, and interoperability program are a few of the other means whereby the AVRADCOM laboratories multiply their RDT&E funding return-on-investment. For example, memoranda of understanding and data exchange annexes are active between AVRADCOM and the Governments of the United Kingdom, Federal Republic of Germany, Japan, Israel, Italy and France in rotocraft technology areas including aeromechanics, unmanned aerial vehicles, composite structures, crashworthiness, and ground-based simulation for application to helicopter controls.

In 1982, the Army Science Board summer study, "Equipping the Army: 1990-2000," concluded that if we are to overcome the Soviet momentum of the last decade, we must capitalize upon the strength of our national economy and technological areas of excellence such as aviation, missiles, space and electronics. The AVRADCOM laboratories are responsive to this realization.

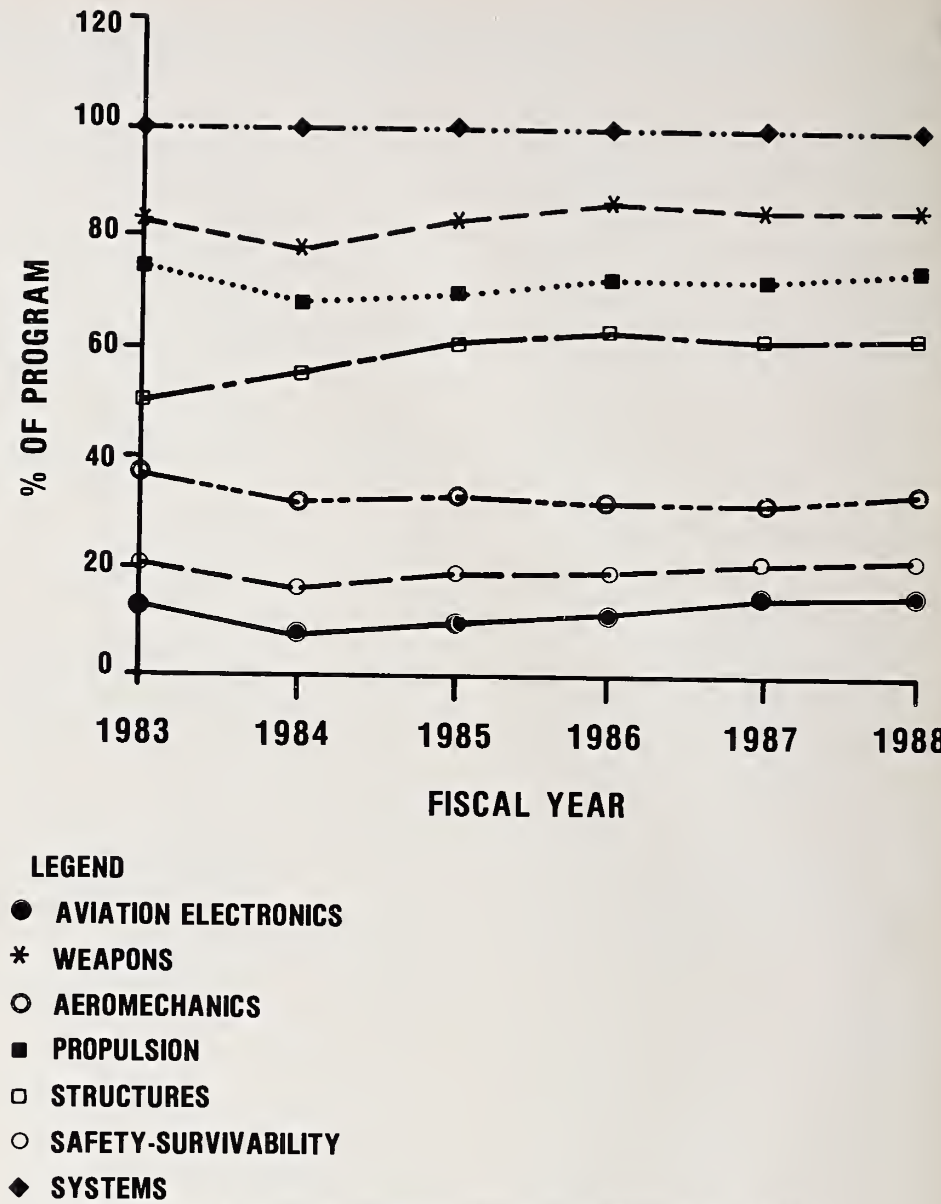


Fig. 2. Army Aviation Technology Breakout (6.1-6.3a)

Aviation electronic technology is providing many opportunities for simplifying materiel and the aviator's workload. A major effort has been the development of an integrated digital cockpit, utilizing MIL-STD-1553 multiplexing techniques.

The first step towards the integration of controls and displays was the integrated avionics control system, AN/ASQ-166. This technology has been transferred to the Coast Guard, Air Force, and Army Helicopter Improvement Program. Building on the successes of the integrated avionics control system, the Army digital avionics system program was formulated. This program defined a new integrated Army cockpit, responsive to both crew and mission requirements, through the use of advanced digital multiplex and display techniques.

The digital avionics system can reduce electrical switches by 56 percent, circuit breakers by 80 percent, control panels by 50 percent, instruments and indicators by 76 percent, and status annunciation by 85 percent while increasing redundancy, improving system reliability, and significantly improving man-machine interface.

Future aircraft employing advanced architectures and digital data buses require more emphasis on the total mission package and consideration of system interaction and integration. A new program, known as future airborne communications equipment and technology, will form a totally integrated communications, navigation, identification equipment, and interactive voice recognition and response technology. This program, along with the development of standard, programmable, multi-purpose controls and displays, will significantly reduce pilot workload.

Building on recent developments of self-contained position/navigation systems, AVRADCOM is addressing promising techniques of hybridizing navigation systems to optimize and extend their performance capabilities in all environments. Hybridizing the global positioning system and doppler, for instance, will retain the inherent accuracies of a doppler navigator, yet allow it to be used over water via external update from the global system.

With respect to airborne navigation

over land, the feasibility of updating the doppler via terrain correlation techniques is being pursued. Instrumental in this approach is development of a digital map as part of the night navigation and pilotage system. This map is needed for maintenance of geographic orientation when flying nap-of-the-earth.

The night navigation system computer will correlate terrain sensing data with stored coordinates on the digital map and automatically update the doppler based on the derived error signal.

The airborne target handoff system is another thrust which capitalizes on integrated systems and is vital to a robust overall aviation command and control capability. The system will enhance the transfer of targeting data and coordination between airborne scout, attack helicopters, and elements of the tactical artillery fire detection system using digital techniques.

In the area of controlling aviation assets, AVRADCOM is developing techniques to provide reliable landing guidance information for aircraft operations in both tactical and non-tactical environments. In fact, the data base developed at AVRADA was used by NASA for the airborne receiver in the space shuttle Columbia.

Structures and propulsion technology programs are addressing many aspects of the Air/Land Battle 2000 with potential for significantly reducing size, weight, cost, fuel consumption, and reliance on critical/strategic materials. The Advanced Composite Airframe Program was initiated in 1981 to demonstrate the advantages of advanced materials and structural concepts utilizing the dynamic components of the Bell Helicopter Textron Model 222 and Sikorsky Model S-76 helicopters. Design analyses have been completed as well as wind tunnel testing of scale models for performance and static stability characteristics. In addition to increasing design flexibility and improving producibility, the airframe program is expected to demonstrate airframe weight and cost savings of 22 percent and 17 percent, respectively. Lightweight, fuel-efficient engines such as the 5000-shaft horsepower Modern Technology Demonstrator Engine and the 800-shaft horsepower Advanced Technology Demonstrator Engine will add to the expected savings generated by the airframe program. The former is a candidate for the CH-47D block improvement and joint services vertical lift aircraft programs.

This engine could decrease CH-47D mission fuel by 19 percent, increase payload range by 36 percent, increase payload capability by 47 percent, and increase productivity by 74 percent.

The 800-shaft horsepower Advanced Technology Demonstrator Engine program goal is to demonstrate improvements in specific fuel consumption of 17 percent to 20 percent as compared to current turboshaft engines in this power class. Both of the competing demonstrator engines have achieved contract requirements during testing.

The Integrated Technology Rotor/Flight Research Rotor program is a joint Army/NASA demonstrator program to combine advances in rotor systems, aeromechanics, structures, materials, acoustics, and dynamics to provide several improvements. Maneuverability/agility for nap-of-the-earth and air-to-air operations will be improved due to increased rotor control power, stiffness and lift capability. Other improvements include: 15 percent reduction in fuel consumption, doubling rotor system fatigue life, rotor system part count reduction by 50 percent, reduce acquisition cost by at least 50 percent and reduction in the use of strategic materials.

The Advanced Digital/Optical Control System will demonstrate the advantages of a helicopter fiber optic flight control system designed to be survivable against the future battlefield ballistic and electronic threat and will demonstrate the mission performance enhancement provided by decreased pilot workload and improved handling qualities.

In comparison to augmented dual mechanical flight control systems, a helicopter fiber optics flight control system will: eliminate electrical interference potential from control system signal paths, reduce the multiple ballistic kill probability by three times, reduce control system weight and life cycle cost by 27 percent, and improve flight safety reliability by a factor of three.

Fire control technology is being advanced to capitalize on the fire-and-forget and automation features of brilliant weapons. The helicopter adverse weather fire control/acquisition radar will provide detection, acquisition and tracking of targets against threats posed at long range, both airborne and ground, moving and stationary, in adverse conditions, day or night, and is an essential for Army aviation to be able to operate in the around the clock, all-weather mode required by the Air/Land Battle 2000 concept.

Unmanned aerial vehicles are a force multiplier and have the potential to perform several alternate missions to those performed by the fire support role of the Aquila. These vehicles could perform electronic countermeasures, radiac survey, chemical detection, meterological data collection, decoy, mine detection, psyops, and munitions delivery. Technologies supporting these alternate missions and the Aquila are being explored by the laboratories in concert with other DARCOM laboratories.

Technology development programs

AVRADCOM DEVELOPED TECHNOLOGY	SYSTEM APPLICABILITY			
	UH-60A	AH-64	CH-47D	AHIP
T-700 ENGINE (WITH ADVANCED COMPRESSORS, COMBUSTORS, TURBINES, AND HIGH-SPEED FUEL PUMPS)	X	X		
ENGINE EXHAUST SUPPRESSION	X	X		X
INLET PARTICLE SEPARATORS	X			
CRASHWORTHY SEATS AND STRUCTURES	X	X		
ELASTIC PITCH BEARING TAIL ROTOR	X	X		X
COMPOSITE MAIN ROTOR BLADES		X		X
ICE PROTECTED MAIN ROTOR BLADES	X			
MODULARIZED HYDRAULIC SYSTEM			X	
COMPOSITE SECONDARY STRUCTURE		X		X
ADVANCED FLIGHT CONTROLS			X	
MULTIPLE CARGO HOOK SYSTEM			X	
BALLISTIC VULNERABILITY REDUCTION	X	X	X	X
CRASHWORTHY FUEL SYSTEM	X	X	X	X
MAST MOUNTED SIGHT				X
AIRBORNE TARGET HANDOFF SYSTEM				X
WIRE STRIKE PROTECTION SYSTEM				X
MULTIFUNCTION DISPLAYS				X

Fig. 3. Application of Aviation Technology.

have been initiated for low and high energy laser countermeasures and for reducing the vulnerability of Army aircraft to the NBC threat. Helicopter battle damage repair concepts have been identified and demonstrated which will greatly increase our ability to sustain combat effectiveness by permitting rapid field repair of combat damaged aircraft. Battle damage repair kits, tools and procedures are being developed.

During 1981, two of AVRADCOM's research aircraft achieved 8 milestones. With proof-of-concept testing complete, the XV-15 Tilt Rotor Research Aircraft was demonstrated at the 1981 Paris International Airshow and the attention it attracted clearly indicates that the U.S. leads the world in this technology. Attendees at the show were not only impressed with the XV-15's ability to fly vertically, backwards, and in conventional forward flight at high speed, but also its silence as compared to the preceding and following demonstrations.

The Advancing Blade Concept program continued in 1981 with flight tests to obtain data on trim and maneuverability at altitudes of 16,000, 20,000, and 25,000 feet (its service ceiling). A maximum speed of 263 knots was attained during the testing. Following the testing, a program review and flight demonstration was held at Fort Rucker, which successfully concludes the flight test program.

Many of the technological advances and design criteria developed through the efforts of the AVRADCOM laboratories have been incorporated in the four latest Army aviation systems: UH-60A Black Hawk, AH-64 Apache, CH-47D modernization, and the Army Helicopter Improvement Program. A sample of these advances is presented in Figure 3.

With a coordinated hierarchy of long-range RDA plans, including the Aviation RDT&E Plan, an accurate forecast of the future threat and technology, a co-operative user/developer relationship, and a healthy technology base program, the AVRADCOM laboratories look forward to contributing to a highly maneuverable, lethal, sustainable Army of the future.

The preceding article was prepared by key personnel at the U.S. Army Aviation R&D Command.

High Mobility Vehicle Models Undergo Testing at APG

Testing has begun at Aberdeen Proving Ground, MD on three candidate models of the proposed High Mobility Multipurpose Wheeled Vehicle (HMMWV).

The nearly 5-month long series of tests will determine which of the candidate manufacturers will be awarded the contract to produce the initial 53,000 vehicles which are intended to become the replacement for all quarter-ton to 5-quarter ton military vehicles.

"The Hummer," as the new vehicle is called by APG's Materiel Testing Directorate engineers, is an outgrowth of two earlier programs which are designed to find replacements for the M151A2 jeep, and the M561 Gamma Goat.

"The jeep goes back 42 years, and the other vehicles date from the late 1950's to mid-1970's. A replacement was needed for them because of tactical limitations, the approaching end of their life cycles, and unexpected high mileage accumulation of tactical fleet vehicles," said Mr. Bill Sulak, assistant HMMWV test director for MTD.

Current joint-Service thinking on off-road military vehicle needs require a standard chassis vehicle which can fill a number of roles.

Specifications for the new vehicle are strict:

- A common chassis upon which several different bodies could be built, such as troop carrier/utility vehicle, ambulance, and weapons carrier.
- The engine must be a diesel with at least 140 horsepower, both for increased power to handle projected heavier loads, and to increase its off-road mobility.
- The vehicle must have power steering, automatic transmission, and run-flat tires capable of moving the vehicle 30 miles at 30 miles per hour (mph) over a paved road while deflated.
- The vehicle must have a 300-mile cruising range, and be able to accelerate from zero to 30 mph in eight seconds or less.

It must also be air transportable by helicopter, and many of the parts must be commercially produced and in use on other off-road type vehicles. On some test models, up to three-quarters of the components came "off the shelf."

MTD has received 21 of the 33 existing prototype models, and has begun a dual test. According to Sulak, six of the vehicles have been designated for performance and safety certification, and 12 have been assigned to reliability, availability, maintainability-durability testing. Three have been assigned to Yuma Proving Ground, AZ, for desert testing.

While at APG, the vehicle will be put through a rugged test program. Each will be driven about 20,000 miles and tested for speed, acceleration, performance on horizontal (side) slopes, grades, inclines, load distribution, braking, traction, steering and handling around obstacles, fuel economy, low and high water fording, cold, and human factors.

The competing vehicles are produced by General Dynamics Corp., which recently bought out the Chrysler Corp. HMMWV effort; Teledyne Corp., and AM General, a subsidiary of American Motors Corp.

Contracts Call for New Chemical Disposal System

Three contracts totaling $852,273 have been awarded by the Army's Toxic and Hazardous Materials Agency (USATHAMA) for the development of an advanced thermal chemical demilitarization system.

Rockwell International of Canoga Park, CA, has received a $330,891 contract, while Battelle's Columbus Laboratories, Columbus, OH, received $261,050 and Midland Ross Corp., Thermal Systems Technical Center, Toledo, OH, got $260,332.

According to Mr. John K. Bartel, chief of USATHAMA's Technology Division, the 10-month contracts will identify improved methods to incinerate nerve agents GB and VX and mustard blistering agents.

An extensive literature search and industrial survey will be conducted to identify existing and advanced state-of-the-art technology related to thermal destruction of lethal chemical agents and similar hazardous organic compounds.

Bartel explained that the thermal systems to be evaluated will include, but not be limited to, conventional incineration, molten salt, fluidized bed and other novel thermal processes that have demonstrated a strong potential to provide enhanced process safety and economics.

The contractors will perform a preliminary engineering evaluation of the alternatives identified and recommend processes that might offer the greatest potential of successful development within a 4- to 5-year time frame.

Communications-Electronics Command (CECOM). . .
Major Efforts Directed Toward Digital Communications

From signal flags to satellites and beyond—that is the 65-year history of the R&D Center of the U.S. Army Communications-Electronics Command (CECOM), headquartered at Fort Monmouth, NJ, with supporting organizations located throughout the U.S. and Europe. Starting with a handful of civilian and Signal Corps military personnel in 1917, the organization now has 1,606 civilian and 199 military personnel, of which 702 are engineers and scientists.

Early experimentation with radio as a military communications asset, the application of the telephone company devices to the Army, and research on the care and handling of carrier pigeons have been superceded by a comprehensive program of development and acquisition of command, control and communications (C^3) systems. These will provide the battlefield commander with the potential for a substantial force multiplier to permit timely and successful execution of assigned missions against the enemy.

To perform its mission, the organization is comprised of three independent but interlocking R&D centers. These carry out advanced and sophisticated research to maintain a technology base for communication and automation equipment and provide engineering support in the design of C^3 systems in which such equipment is used.

CENTACS Teleprocessing Design Center's Microprogrammable Multi-Processor System.

Center for Communications Systems

As the title implies, the task of this center is to conduct R&D of Army communication equipment/systems. A major goal is to provide an all-digital communications capability through all levels of the Army so as not to limit mobility and operational tactics. The approach to implementation involved the establishment of three major product lines.

The first product line concentrates all those efforts which directly contribute to increased mobility, i.e., weight and size reductions, remote location of antennas, elimination of wire and cable, reductions in the size and number of antennas, and rapidly deployable antenna masts.

Providing techniques and equipment designed to reduce physical and electromagnetic signatures, improving survivability against both conventional and nuclear attack, avoiding detection and interceptions, and resisting enemy jamming are efforts which comprise the second product line.

The last product line provides systems and techniques to enhance system survivability via use of redundancy, nodeless distributed networks, and adaptive, responsive control techniques.

Technology thrusts in eight major areas then feed into these three product lines from which the actual "deliverables" in terms of communications hardware emerge. Within this fundamental technology strategy, the emphasis is on: fiber optic development; millimeter wave development; digital microwave development; propagation research; antenna research; high frequency radio development; imbedded communication security; and battlefield information distribution system.

In accomplishing the above, approximately 90 separate tasks are being pursued covering all phases of the R&D cycle from research to fielding. The most noteworthy of these involve fiber optics, millimeter wave communications, modern high frequency radio equipment and tactical packet switching.

In the past five years, fiber optic technology has gone from a laboratory curiosity to a multi-billion dollar industry. It was eight years ago that the Army saw the possibilities of this infant technology and began programs to make use of its unique properties.

Apart from the obvious applications of replacing the current heavy twin coax and 26 pair cables with the more rugged fiber optic cable, CECOM is pursuing, jointly with the Missile Command (MICOM), the fiber optic controlled guided missile. This missile has a TV camera in the nose and pays out an optical fiber. TV picture information and missile guidance commands are carried up and down the fiber in the form of pulses of light. The operator can then fly the missile as if he were in it and yet be completely concealed from the enemy. The electronics and the fiber optic data link developed at CECOM were successfully tested at MICOM during a recent live missile shot.

Another exciting program is that involving air layable fiber optic cables. Smaller than the cable developed to replace twin coax and 26 pair, this cable is still rugged enough to be deployed by helicopter. In a recent flight test with the Air Assault Division at Fort Campbell, KY, five miles of cable was deployed at speeds up to 130 miles per hour. The cable is smaller than field wire and can be also easily deployed by back-pack.

A tactical packet switching system (TACPACS) is essential to satisfy the communications needs among and between the five battlefield functional areas (intel/EW, fire support, maneuver control, air defense, combat service support). TACPACS will have the capability of accepting information from any battlefield functional area processor-based system whether it be voice, data, video, message, facsimile, realtime or system control and deliver it to any or all other battlefield functional area systems. It will utilize microprocessor-based gateway interfaces to any system for the receipt and delivery of information, while the system itself will be highly dynamic and distributed utilizing adap-

tive network management techniques.

TACPACS, will be an inherently reliable, responsive and survivable switched information distribution system to support large numbers of subscribers with widely varying needs. This generic common-user switched distribution and communications system would integrate the numerous and diverse information types, reduce the resources for their support and help eliminate intersystem interoperability and internetworking problems.

Combining the covertness of cable communications with the mobility and bandwidth of traditional radio communications is the thrust of CECOM's millimeter wave radio program. From the theoretical analysis of radio communications above 30 GHz in the mid-1970's to the on-going world-wide user evaluation of new concepts and hardware, CECOM continues to lead DOD in the development of such tactical radio communications.

With these radios, survivability on the modern battlefield is greatly enhanced. Covert wireless local distribution, command post remoting, vehicle-to-vehicle communications and cable replacement are now possible with millimeter wave radios, and initial fielding of the first radios will be in 1987.

After being dormant for nearly 15 years, due to satellite communications prominence, a need for an HF radio was resurrected to fill the void for extended range communications, beyond tactical VHF radios, and to supplement satellite links.

Technical and operational shortcomings of the current generation of tactical HF radios were compiled and a development plan for an objective HF radio system to be fielded in the early 1990's was formulated. Electronic counter-countermeasures, an electronic means to counter hostile jamming, was selected as the first technical challenge to be solved.

Thus far, frequency hopping waveforms and modulation characteristics have been identified. Other areas of development, which have been initiated or will be in the near future, are automated features enabling the radio to adapt to the ever-changing environment thereby reducing operator training.

Of particular note is a new Communications System Design Center that is rapidly nearing completion after five years of planning and implementation. It will be a comprehensive facility for receiving, operating, testing, and evaluating prototypes of any level of complexity, as well as fielded communications devices, and for modifications to them, in a controlled laboratory environment.

This will be accomplished by the integration of communications functional modules into various secure systems or network configurations which will contain tactical equipment; special purpose simulators; commercial communications subsystems; and fiber optics, cable, terrestrial radio and satellite test ranges; and a sophisticated data collection and reduction capability. The facility layout and capability to test and experiment will be flexible enough to conduct extensive communications system analysis and address tactical communications issues such as:

- Integration of newly developed equipment items into existing configurations.
- New concepts for employing existing equipment assets.
- System level degradation analysis based upon simulation of predictable problems and problems being reported by field users.
- Feasibility and suitability of proposed concepts for new equipment items or systems.
- Design integration and testing of proposed product improvements.
- Imbedded COMSEC

The communications system center has an authorization of 224 civilians and 5 military, which includes 151 scientists and engineers—59 percent of whom had advanced degrees—an exceptionally high level of professional competence.

Center for Tactical Computer Systems

A four-fold mission exists for the Center for Tactical Computer Systems. These include carrying on technology base R&D programs in tactical computer sciences and systems, developing multi-application tactical computer hardware and software, serving as the DARCOM/agency focal point for engineering support of tactical computer-based systems, and providing post deployment software support for the communications battlefield function area.

CENTAC's activity in these crucial mission areas provides extensive support in multi-application computer areas. Significant programs include: the military computer family; the military computer family peripherals; the Army's Ada language system; a family of transportable software tools and products; computer resource management; the teleprocessing design center; and post deployment software support.

In line with the overall CECOM thrust of improving the Army's present C^3 posture as quickly as possible without neglecting the long term needs, the tactical computer center concentrates its efforts in several areas. Among these is the military computer family program, aimed at providing a standard compatible family of highly reliable computers and computer peripherals, such as dislays, for use in communications, command, control and intelligence systems applications.

The acquisition strategy is aimed at increasing system survivability and maintainability while reducing the cost of support and training through elimination of the many different types of hardware now in use that perform similar functions. This makes the systems more survivable since computers and peripherals can be interchanged from a less critical system to a critical system if the latter becomes inoperable during battle. The approach also provides for insertion of the latest technology to eliminate the problem of obsolescence.

As well as standardizing on a small set of computers, the Center is also developing an Army standard high order computer language system using the DOD standard high order language, Ada. This standard language is to be used on all the Army's battlefield systems that contain computers. Using one computer language simplifies training and support and considerably reduces future costs of new or modified software for existing systems.

The Center continues to support the Army's standardization efforts with respect to computer resources and computer resource acquisition. This involves the generation of enforceable policies, procedures, guidelines and standards for cost-effective management of computer resources. A series of nine guidebooks covering all aspects of the problem have been prepared. Much of this effort is directed toward assisting project managers and system developers in producing cost-effective software throughout the system life cycle.

Through the cooperative effort of DARCOM personnel and all of the major subordinate commands, the Center conducted a far-reaching study to establish an approved concept plan for post deployment software support for Army tactical computer systems. Key aspects of the plan are:

- Eleven software support centers for fielded systems within DARCOM-subordinate commands.
- A laboratory at Fort Monmouth to provide this support to tactical communications systems from Fort Monmouth.
- The Fort Monmouth facility will

house systems being developed by CECOM project managers, Satellite Communications Agency, and certain Air Force and Marine systems under the Joint Tactical Communications Office, Aviation R&D Command, and the U.S. Army Electronics R&D Command.

The major development facility within CENTACS is designated the Teleprocessing Design Center, and is used to test and validate all aspects of the design of Army and joint service data sytems configurations.

A key element of the facility is the microprogramable multi-processor, an integrated group of computers, which has the capability of simultaneously emulating multiple tactical data systems to study their interactions, weaknesses, inconsistencies and possible improvements without having to use the actual systems. The facility is continuously being upgraded and expanded to handle new technologies.

CENTACS has an authorization of 166 civilians and 38 military, which include, on-board, 85 professionals; more than 50 percent of the group hold advanced degrees and have a substantial amount of specialized computer science training and experience.

Center for Systems Engineering & Integration

The third center of this command dealing with systems engineering and integration, serves as the Army's tactical C^3 system engineer. The goal of the 149-man Center is to establish a cohesive, well-engineered, affordable, and evolutionary system design that integrates the component fire control, air defense, intelligence/EW, maneuver control, combat service support, and communications facilities into a single overall system to provide for effective command and control of Army tactical forces at all echelons.

Major activities include: command, control, and communications system engineering; interoperability and standardization planning for the Army on joint service, DOD, national, and international levels; maximizing intersystem compatibility and commonality; interfacing with Army users to develop requirements, evolve system architecture, and ensure effective exploitation of advanced technology; supporting joint and intra-Army testing, including managing the Army Interoperability Test Unit; and managing Army use of the frequency spectrum.

The Army-wide tactical C^3 system engineering program, which was tasked to the Center as a result of Army approval of the Army command and control master plan, was successfully begun with methodology, outlines, and definitions for specifications development. The Army Command and Control System (ACCS) Engineering Implementation Plan was written to outline a methodical approach for development of the tactical C^3 system including specification development and interface testing.

A series of functional analyses have been prepared as the first step in specification development. Fire support, maneuver control, and air defense functional analyses have been completed and corps and division operational subsystem analyses are in progress. These functional analyses are being used in preparation of specifications for fire support and maneuver control functional segments. Initial specifications prepared under this program have verified and refined the basic methodology that had been established earlier.

FIELD TEST of a Millimeter Wave Radio System designed to provide short-range intercept resistant communications.

As the lead Service activity for the management of the DOD standardization area for tactical communications systems technical standards, the Center completed development of interface specifications for the enhanced Position Locating/Reporting System user unit and the Joint Tactical Information Distribution System Class II full-scale development terminal interfaces with the host systems that have been designated to participate in the combined hybrid system test bed. A series of interface specifications for interfaces among ACCS elements is also being prepared.

The first processing element of a mini-computer-based-four-echelon tactical frequency engineering pilot system has been installed in Europe to provide a "now" or "go to war" asset for battlefield spectrum management, if needed. This initial operational capability includes circuit routing and status keeping for multichannel networks, frequency assignment for multichannel radios, and terrain profiling and propagation prediction to support network planning and engineering.

Currently there are significant activities in the network survivability and management areas. Distributed processing and distributed command post techniques are being developed for improved C^3 survivability. Survivability analysis methodology and surrogate satellite systems are being investigated as are network management techniques for combinations of model and nodeless systems.

The Center also operates the Army Test Unit, a computer instrumented, secure test facility that includes a remote user interface unit for accessing the JINTACCS Joint Interface Test Facility (JITF). The facility includes secure voice, data, and teletypewriter terminal equipment, automatic data processing equipment, patching equipment and test monitoring facilities.

The U.S. Army Communications-Electronics Command is proud of its past record and it looks forward to a highly productive future thanks to a capable and highy motivated workforce.

The preceding article was prepared by key personnel at the U.S. Army Communications-Electronics Command.

Many Technologies Used...

ERADCOM Labs Focus on Providing the 'Winning Edge'

Like a large modern American corporation, the U.S. Army Electronics Research and Development Command (ERADCOM) is composed of seven laboratories, two of which have subordinate activities, two project managers, and an aircraft support activity. These elements are dispersed through 10 different locations in four states, and the command operates on a budget of $1.2 billion with a staff of 4,000 administrative and technical personnel.

Committed to providing the Army with the winning edge—the finest combat electronics materiel necessary to win the war—ERADCOM uses many technologies to achieve this goal; microelectronics, millimeter waves, electro-optics, radar, atmospheric obscuration, signal processing, countermeasures/countermeasures, fuzing, nuclear weapons effects, jammers, lasers, integrated circuitry, and multisensors.

These technologies underpin a command long-range plan which supports 7 of the 10 Army mission areas. ERADCOM technologies are subsets of the Army's newest major weapons, e.g., the M1 Abrams tank, the Patriot missile and the Advanced Attack Helicopter.

Established in 1978, ERADCOM is the newest of DARCOM's commands. It is collocated in Adelphi, MD with one of its elements, the Harry Diamond Laboratories, five miles outside the District of Columbia.

ERADCOM Headquarters and Harry Diamond Laboratories, Adelphi, MD

Electronics Technology & Devices Laboratory

The Electronics Technology and Devices Laboratory is one of the command's three labs that focus on their research, as well as critical components, particularly for highly mobile distributed battlefield systems and their logistics support.

The laboratory draws upon many technologies including millimeter wave and pulsers for location and identification of targets through smoke and fog, high speed signal processing, microelectronics for compact, secure data links, C3, and navigation.

Past breakthroughs have included the areas of low cost millimeter wave dialectric circuits, lithium non-rechargeable batteries, flat panel displays, brassboards megawatt modulators for high energy beam weapons, and new electronic materials and processing techniques for acoustic wave signal processing devices.

Currently, more than 40 critical technology products are under development at ETDL that will have application over 100 Army electronic systems.

Key ETDL technology areas include molecular beam epitaxy, E-beam lithography, ion implantation, and ion scattering spectroscopy/secondary ion mass spectroscopy. More than 68 percent of the lab is devoted to R&D.

ETDL is also the Army's principal manager of the Army's portion of DOD's very high-speed integrated circuits program—a major undertaking aimed at upgrading the design and production of the microelectronics.

Harry Diamond Laboratories

The Harry Diamond Laboratories—HDL, another of the command's basic research centers, is widely known for its work in proximity fuzing. However, the laboratory has diversified into other fields. Improving the survivability of Army materiel on the nuclear battlefield is now an important HDL mission along with near millimeter wave sensors and defense systems against antiradiation missiles and signal recognition.

Originally part of the National Bureau of Standards, where two of its staff developed the first proximity fuze during World War II, the activity became the Diamond Ordnance Fuze Laboratory in 1953 when it was transferred to the Army. In 1962, it became HDL.

HDL is well known for its work in nuclear weapon effects, fluidics, near millimeter wave, and radar technology as well as fuzes. R&D activities include nuclear simulators, conformal radar antennas and near-millimeter wave transmitters and receivers, reserve power sources, surface acoustic wave devices, computer aided design and graphics, and microelectronics.

Through its antiradiation missile countermeasures program and nuclear effects support team, HDL supports both DARCOM and DOD. The lab also operates the world's largest gamma-ray simulation facility and a threat level electromagnetic pulse simulator.

During the past five years, HDL developed and type-classified five fuzes, some of which use highly electronic countermeasures resistant decision circuits. All the Army's nuclear delivery capability has been hardened by HDL through its nuclear weapons effects program.

Two unique near millimeter wave transmitters sources, the Orotron and Gyratron, have been developed and several novel signal processing devices using surface acoustic wave effects have been demonstrated.

Other HDL physicists have discovered a large number of new radioactive transitions in various gases, potentially useful for laser sources of near millimeter wave radiation.

Recently HDL has begun applying gun-rugged fuzing technology to expendable jammers, and an exciting new thrust for HDL is its new mission, supporting the Army's battlefield data systems, an airborne radar.

Located on 137 acres at Adelphi, MD, HDL also has an electromagnetic pulse laboratory at Woodbridge, VA, and a large test site at Blossom Point, MD.

HDL's budget is $118 million in FY 82 of which approximately $65 million is for in-house operations. The staff consists of 1,200, including 350 technical professionals, over half with advanced degrees.

Historically, HDL was operated under the Army Industrial Fund and today is still largely funded by project managers, other Army major commands, other Services and outside agencies.

Night Vision & Electro-Optics Laboratory

The Night Vision and Electro-Optics Laboratory (NVEOL), third basic research establishment of the command, is at the cutting edge of electro-optical technology.

In fulfilling its mission to make military operations as effective at night as during the day, NVEOL focuses on development of systems which will act as force multipliers by extending the sensory perception of the soldier on the battlefield.

In recent years, the laboratory has fielded passive night vision devices and, more recently, small laser rangefinders.

Development is now under way on systems that perform effectively in conditions of limited visibility. The two techniques used are image intensification and thermal imaging (far infrared) —relatively new concepts in military operations. They are passive, that is, they emit no radiation and are undetectable.

Image intensifier developments at NVEOL have reached the third generation stage at which the photocathode tube demonstrates much lower light levels.

Unlike image intensifiers, far infrared sensors see during darkness and time of poor visibility by detecting and displaying very small temperature differences between objects and their backgrounds. Camouflaged targets and other targets hidden by light foliage are easily seen with thermal imagers. Because these devices are much more complex and expensive than near infrared systems, "building blocks" of common modules are used in all far infrared systems. The common module approach is the first step in a revolutionary technology to provide better-seeing, smaller and lighter devices.

AN/AVS-6 Night Vision System

Recently, NVEOL achieved initial operating capability for the night sight (AN/TAS-4), for the tube launched, optically-tracked (wire-guided) (TOW) weapon system, completed development and operational testing of the advanced night vision goggles (AN/PVS-7) and entered high volume production of four thermal systems, including night sights for the TOW and Dragon (AN/VSG-2) and thermal night observation devices (AN/TAS-6). More than 1,000 systems have been produced and fielded in the last two years.

Located at Fort Belvoir, NVEOL has a staff of nearly 500, and a budget of $240 million, $26 million of which is for inhouse operations.

Combat Surveillance & Target Acquisition Lab

The Combat Surveillance and Target Acquisition Laboratory (CSTAL) is the most historical of all ERADCOM's seven laboratories. Once the location of Marconi Wireless, the forerunner of the Radio Corp. of America, this site, known as the Evans Area, was used to demonstrate the forerunner of the nation's first radar used at Pearl Harbor. Here, the inventor of frequency modulation, Mr. Edward H. Armstrong, first tested his regenerative receiver bringing in clear radio signals from overseas.

The CSTAL focuses on radar design and development. During the last decade, ground and airborne systems developed at CSTAL include the manportable radar to detect tactical moving targets and the side-looking airborne radar that surveys the battlefield from the air.

The Mobile Army Ground Intelligence and Interpretation Center system was fielded in May 1982; new miniature, multipurpose radiac devices are now being tested; development of the new Meteorological Data Testing is almost complete; and new Identification Friend or Foe systems for non-cooperative identification of ground and air enemy vehicles is in development.

Acoustic techniques in weapons location systems are being improved and incorporated into a radio data link that ties field sensors to the base recorder and processor. This will eliminate the Army's old hard-wired system and will enhance its ability to locate enemy fire.

The 200-person workforce at CSTAL includes 125 scientists and engineers, and the budget for CSTAL in FY 82 is $19 million. This sum is divided between research and development and equipment procurement.

Electronic Warfare Laboratory

To provide the Army with an electronic warfare capability to counter battlefield threats and assure effective operation of our electronic systems in a hostile "EW" environment is the job of the Electronic Warfare Laboratory.

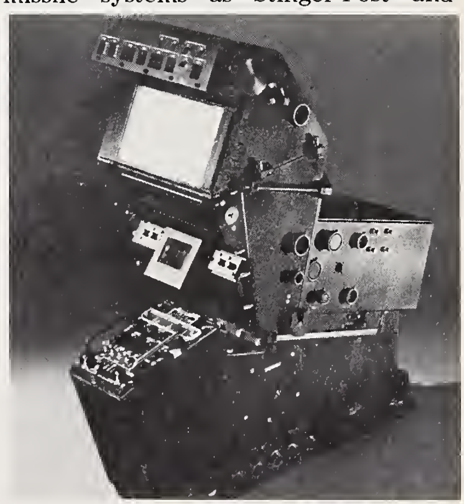
This laboratory has prime responsibility for EW protection of combat systems, hardening of communications-electronic and missile systems against enemy EW technology, and certain intelligence materiel and support.

EWL also has project officer leadership for communications and non-communications expendable jammers, and heads the program to integrate both communications and non-communications emitter location/identification Army systems into a single airborne platform.

Emphasis at EWL is on development of the supporting technology base and aggressive transition to field equipment. For example, in the area of self-protection, a variety of radar, IR, and optical threat warning devices, responsive jammers and decoys, along with their integration into EW suites for helicopter and fixed-wing aircraft, have been fielded.

A comprehensive program for expandable jammers is under way in the area of ground-based airborne EW systems.

Missile systems EW vulnerability and test analysis is conducted on such key missile systems as Stinger-Post and



APS-94E, Side-Looking Airborne Radar for fixed-wing aircraft, provides near real-time detection of moving targets.

Patriot, and a strong technology measurements and intelligence base is maintained against evolving threats.

Communications-electronics systems vulnerability assessments of systems such as Position Location and Reporting System and AN/TPQ-37 have led to numerous ECCM corrections, and a Steerable Null Antenna Processor to defeat enen y jammers is in production.

The laboratory, operating with a $22 million budget, has a staff of 407 of which 219 are engineering and scientific professionals.

AN/ALQ 151 elctronic countermeasure system, developed at the Signals Warfare Laboratory, has intercepting, jamming and direction finding capabilities.

Signals Warfare Laboratory

For the development of communications signals intelligence/electronic warfare systems to be deployed at various echelons from division and below through echelons above corps, the Army looks to the Signals Warfare Laboratory. In carrying out its assigned mission, the lab must respond to the tactical and strategic requirements in these areas of the Army and the National Security Agency.

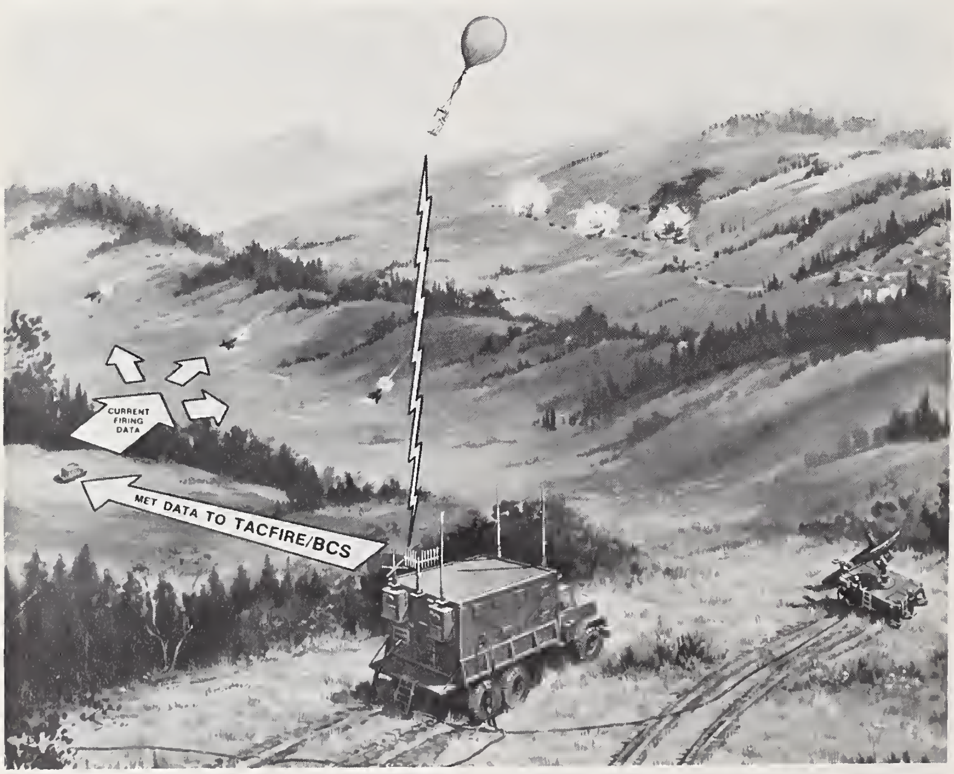
Systems developed by SWL are integrated into the Army's combat electronics warfare and intelligence units as well as fixed installations operated by the Army Intelligence and Security Command.

With an integrated technology based program covering 27 areas, and supporting DARCOM and TRADOC long-range requirements, SWL has significantly advanced the Army's intelligence and electronic warfare status. The National Security Agency has designated SWL as the lead laboratory in developing and fielding a tri-service rear echelon high-frequency communication intelligence system. SWL also has program responsibility for developing and fielding a digital storage recorder for field station use.

Some of the more recent key SWL products include Tacjam (ANMLQ-34), a highly mobile tactical communications countermeasure system used in the VHF frequency range. It can jam virtually any conventional communications emitter in its frequency range; Traffic Jam (AN/TLQ-17A), a tactical communication electronics countermeasure system; and Trailblazer (AN/TSQ-114), a division level, mobile, communications intercept and location system to operate in a specific frequency spectrum.

Additionally, SWL developed Quick Fix (AN/ALQ-151), the tactical airborne EW capability which includes signals intercept, direction finding and jamming; MRDFS (Man-Pack Radio DF System), a lightweight man-transportable, quick-erecting communications intercept and DF system for the Army and Marine Corps; and Homerun/Superfly, an inexpensive seeking head on a lethal countermeasure drone to be used against communication nodes.

Expendable jammers, both hand emplaced and artillery delivered, will provide the Army with a synergistic effect in electronic warfare capabilities.



Meteorological Data System—AN/TMQ-31 is being developed by the Combat Surveillance and Target Acquisition Laboratory to provide the Field Artillery with a highly mobile, lightweight, automatic data processing, non-radiating meteorological data acquisition and processing system.

Atmospheric Sciences Laboratory

The future battlefield will hold an elaborate blend of sophisticated combat weapons, all profoundly affected by the atmosphere. The mission then, of the Atmospheric Sciences Laboratory (ASL), is to increase the combat effectiveness of these weapons by understanding weather and obscuration problems which affect weapons operations.

In developing Army requirements to use the atmosphere as a force multiplier without a profusion of meteorological equipment on the battlefield, ASL first studies the problem from five angles: system design is reviewed to ensure that atmospheric technical assessment has been included; knowledge of present atmospheric effects on these systems is incorporated to give them an all-weather capability; techniques are developed to mitigate atmospheric effects; at-

mospheric sensors that can be integrated into other Army multipurpose systems are developed; and meteorological measurement systems for battlefield environments are also developed.

ASL, the only Army laboratory dedicated solely to researching atmospheric effects on weapon design and operation, is located at White Sands Missile Range in the historic Tularosa Basin in New Mexico. The basin, once the site of Indian battles, is now the home of the White Sands Missile Range, the largest land-area military base in the country, with ASL as its largest tenant.

The need for meteorological information in battle has grown rapidly from its beginnings following World War II in support of the V-2 rocket program. Since 1969, all activities involved in weather-related weapon problems were combined at White Sands under the command of ASL.

A high technology laboratory, ASL centers on fundamental and applied research, emphasizing technology for Army materiel development and testing. It is the lead Army lab for the DOD Tri-Service High Energy Laser Program and several Army areas including artillery meteorological and electro-optics climatology and atmospheric optics data bases. Currently, ASL scientists are working on the atmospheric effects on modern weapon systems and the development of tactical remote atmospheric sensing.

The output from ASL has been considerable. One of the major products in recent years is the Electro-Optical Systems Atmospheric Effects Library, a munition expenditure model KWIK, the Meteorological Data Set, and the Automatic Meteorological Station System.

A battlefield commander can, through the Electro-Optical Library quantify the obscuration effects of the dirty battlefield in such areas as system design, performance analysis, test and evaluation, and wargaming. This library was distributed to NATO and to more than 35 government and contractor organizations.

The Meteorological Data Set (AN/TMQ-31) and RAWS (AN/TMQ-30) both provide meteorological information to battlefield units. The former, targeted for fielding in the mid 80s, furnishes upper atmospheric data to improve the accuracy of artillery.

An ASL workforce of some 200 civilians and almost 300 military is responsible for the meteorological program in ASL. Twenty-seven percent of the civilians have master's or doctorate degrees. An additional 25 percent hold bachelor's or associate's degrees.

The preceding article was prepared by key personnel at the U.S. Army Electronics R&D Command.

Easier Method Used for Nerve Agent Detection

Department of Defense medical facilities are now using a simplified and time-saving method to discover the presence of nerve agents in the bloodstream. The method was developed 10 years ago by Dr. Robert Ellin of the U.S. Army Medical Research Institute of Chemical Defense, located in the Edgewood Area of Aberdeen Proving Ground, MD. Ellin, acting chief of the Analytical Chemistry and Bioassay Branch, said his method has "a simplified means of measuring cholinesterase activity in red blood cells."

"It's an important enzyme present in blood and body tissues. It is responsible for the normal transmission of nerve impulses," Ellin explained. "The lowering of enzyme activity is most likely an indication of exposure to some agent."

Ellin said he developed his method as the result of a project in 1972 and had it published in the Archives of Environmental Health, American Medical Association, in 1973.

It was adopted by the Army about a year ago and initiated at Fitzsimons Army Hospital, Denver, CO, for the purposes of controlling and standardizing the technique.

A major advantage of Ellin's method is the shorter sampling period. The Michel method, which has been in use since 1949, required a 60-minute sampling period. Ellin's method requires only 17 minutes.

According to Ellin's published report, this modification in time "would be useful in cases where a rapid report of enzyme activity is required to determine whether or not a person has been exposed to an anticholinesterase compound and also when the assay of small numbers of samples is required."

Ellin's method was selected for its simplicity and precision. It is relatively easy to learn, saves time, and can be performed by technicians in field hospitals.

A similar method has also been developed for use with blood plasma, which cuts the sampling period to 13 minutes. However, Ellin hasn't published this method as yet.

Ellin, who won an Army R&D Achievement Award in 1973, has spent 27 years with the government, all at Edgewood. He was educated at Johns Hopkins University and the University of Maryland, and taught for five years at the University of Rhode Island, College of Pharmacy, and has authored 80 publications.

Mobility Equipment R&D Command (MERADCOM). . .

7 Labs Conduct Programs in Diverse Fields of Endeavor

Will the Army of the 1990's and beyond be able to move its combat forces across natural and artificial obstacles, have fuel and electric power to keep its equipment operating, have protective equipment to avoid being seen and hit?

Will the logistical forces be able to provide the needed myriad of supply items—including water?

These are a few of the technical problems being tackled by the U.S. Army Mobility Equipment Research and Development Command (MERADCOM), at Fort Belvoir, VA.

To develop a logical, consistent, and forward-moving work program for its laboratories, MERADCOM must exchange information with many outside agencies. These include DARCOM for funding and program guidance, the TRADOC community for current doctrine and requirements, and military project managers for needs peculiar to their systems. From this continuing information exchange, MERADCOM annually updates its Mobility Equipment R&D Plan to insure that its work program is responsive to Army needs.

An important element being introduced with the FY 82-83 planning cycle is a focus on future requirements as foreseen by TRADOC. MERADCOM managers have incorporated the Airland Battle doctrine and the Airland Battle 2000 concept to provide direction for the Command's future efforts.

MERADCOM's diverse fields are demonstrated by programs and capabilities of its seven Laboratories.

Countermine Laboratory

The Countermine laboratory's mission is associated with a unique military function—detection and neutralization of hostile land mines.

One of several current mine detection programs, which overcomes a number of technical and operational constraints, is an approach called "Enzyme Immunoassay." Certain enzymes interacting with specially bred antibodies were found to be specific in sensing explosive vapors. An amplified light-emission reaction increases sensitivity of the enzyme sensor and provides an extremely sensitive detection method.

New approaches to mine neutralization are being pursued to overcome the problems of weight, bulk, and "skip-zone" effects associated with use of the conventional explosives long used in this role. Fuel Air Explosive (FAE) warheads are effective over a much wider area due to their distributed explosive cloud. A significant breakthrough technique for neutralization utilizes dispersed explosives to achieve much higher overpressures than possible with a conventional FAE warhead.

Counter Surveillance Counter Intrusion Lab

Research in the fields of physical security, camouflage, deception, topographics, tactical sensors, barriers, special purpose detectors, tunnel detection and field fortifications, is the job of the *Counter Surveillance/Counter Intrusion Laboratory.*

Facilities available for counter surveillance research include a radar diagnostic facility to measure and pinpoint radar returns and a number of spectrophotometers for analysis of the infrared reflectivity of camouflage coatings. Counter intrusion facilities include an anechoic chamber and laboratories for the design, construction, and testing of a wide variety of sensors.

A recent project was the development of the Facility Intrusion Detection System, commonly referred to as FIDS, a highly secure and modern microprocessor-controlled system for joint services applications. Sensing technologies investigated during FIDS development included seismic, magnetic, acoustic, electromagnetic, and infrared.

Electrical Power Laboratory

The Electrical Power Laboratory is responsible for research, development, and engineering support for mobile electric power sources, heaters, air conditioners, general purpose lighting, and power distribution systems. These items are essential to Army weapons, communications, and support systems. Facilities and equipment are being developed for electric propulsion research and tests to predict how battery-powered vehicles will perform under simulated field conditions.

Silent electrical power sources are a major neeed for the future, and to obtain this capability the laboratory is developing a family of fuel cell power plants which use methanol and other unconventional fuels. Research efforts continue on the development of direct oxidation fuel cells for higher performance with less weight and volume.

In addition to its work with fuel cells, the laboratory develops power generation equipment and environmental systems for weapon systems like the Patriot missile system and the Firefinder mortar locating radar, and is also the lead agency for the evaluation of electric vehicles and the applications of solar energy within the Department of Defense. .

Energy & Water Resources Laboratory

The Energy and Water Resources Laboratory is concerned with developing fuels, lubricants, grease, preservatives, power transmission fluids, and related products. In addition, the lab studies alternatives to conventional fuels, such as gasohol and shale oil and coal products. Also included in its mission is the development of systems for handling, distribution and storage of bulk POL and water; water purification equipment; equipment and techniques for pollution abatement; and fire fighting and fire supression equipment.

In a major effort in FY 81, the laboratory designed and placed production contracts for a complete water supply and distribution system for the Rapid Deployment Force.

Major efforts in the area of fuels and

lubricants are improving the survivability of combat equipment by developing new fire-resistant fuels and fluids, developing new and improved products and increasing the use of synthetic and alternative fuels, and insuring that new and existing fuels and lubricants are compatible with the Army's many and varied weapon systems.

Marine & Bridge Laboratory

The Marine & Bridge Laboratory is responsible for research and development in supply distribution and counterbarrier systems. The supply distribution area covers a broad development and modernization effort in marine vessels such as tugs and harbor service craft, logistics support vessels, landing craft, barges and amphibians. Currently, special emphasis is being placed on the application of air cushion vehicle technology to Army amphibious applications.

In support of the supply distribution/marine craft engineering effort, MERADCOM has a naturally protected basin in close proximity to the main shipping channel of the Potomac River. The basin is primarily used for testing and demonstration of prototype small craft.

The laboratory's counterbarrier program consists of bridges that can be transported, erected and retrieved without a heavy concentration of men and equipment, and employs computer-aided design techniques in conjunction with the classical design methods in the creation of bridge system designs. Engineers have structural analysis programs available for the development of models for both component and system design.

Laboratory scientists are investigating the use of advanced composite materials to achieve improvements in current designs. An important future prospect is a conceptual design for a long-span tactical bridge using high strength alloys and a number of composite components.

A complete in-house bridging test capability is maintained for a wide range of prototype testing such as static and dynamic structural tests, bouyancy tests, flotation tests, and trafficking.

Material Technology Laboratory

The Material Technology Laboratory is the focal point for materials research and development within MERADCOM. It provides a broad spectrum of materials services from basic research to testing and evaluation in organics, chemical coatings, chemistry, rubber, coated fabrics, adhesives, plastics, ceramics, metallurgy composites, radiation and packaging.

This laboratory is the lead laboratory within the Army for coatings research. It is responsible for all coating specifications within DOD and is presently reformulating coatings to meet the Clean Air Act, Toxic Substance Control Act, and Occupational Safety & Health Administration (OSHA) requirements.

The laboratory's Rubber and Coated Fabrics Research Group is rapidly becoming the Army's focal point for applied research in elastomerics. This group's major current effort is material development for arctic fuels handling equipment, including polyurethane fabric collapsible fuel tanks, drums and hose.

The laboratory staff includes chemists, metallurgists biologists, engineers and physicists. Because of the wide variety of materials questions which arise in the course of command-wide development efforts, the laboratory requires extensive facilities and instrumentation. Some of the equipment available includes scanning electron microscopes, infrared spectrophotometers, a 3/4-meter spectrograph, atomic particle counters, and optical chromatographic equipment.

Mechanical & Construction Equipment Laboratory

The Mechanical and Construction Equipment Laboratory performs application and development engineering of equipment to meet the Army's combat, mobility, and logistic support needs in construction equipment, supply distribution and materials handling equipment, railway equipment, diving equipment, maintenance equipment, compressors, and gas generating equipment.

In the area of construction equipment capability, a new generation of airborne/airmobile earthmoving equipment is being introduced to support airborne operations. The family includes graders, loaders, scrapers, water distributors and two sizes of dozers. In addition, a highly mobile entrenching machine is being evaluated for infantry support.

The laboratory's technology-base effort in materials handling and supply distribution has focused on forward resupply of ammunition. This focus is to develop a technology base which will resupply ammunition at high rates under forward combat conditions and the NBC threat.

Various concepts were selected for a technical feasibility analysis for FY 82, including using robotic technology to transfer ammunition clips into the combat tank and howitzer from an armored resupply vehicle; a multi-projectile compatible conveyor to reconfigure/assist in ammunition handling at the rearm/refuel point; and using robotic technology to repackage tank and artillery ammunition from shipping configuration into user-oriented packages.

MERADCOM's laboratories have access to some of the finest facilities in the Army, including environmental test chambers, a railway test hump, tilt tables and test tracks, model fabrication shops, minefield lanes, a hydraulic bridge test frame, a CYBER 170-730 Computer, and devices to study electrokinetic and other means of decontaminating fuel.

These facilities are located in 40 permanent buildings on MERADCOM's 240-acre main complex and in an 820-acre test area near Springfield, VA. The command also directs the activities of the Army Fuels and Lubricants Research Laboratory, a government-owned/contractor-operated facility at Southwest Research Laboratory near San Antonio, TX.

The heart of MERADCOM's operation is its 1,172 civilian and 63 military personnel, including 391 engineers and scientists. The command has a FY 82 budget of $344 million of which some $85 million have been designated for research, development, test and engineering. The remainder is divided into $26 million for operations and maintenance and engineering support, and $233 million for procurement.

As an Army Laboratory, MERADCOM has one of the most diverse missions assigned to any of the Army's research and development organizations. Equipment developed by the command moves supplies, powers equipment and weapons, clears paths and bridges gaps, provides fuel and water in forward and rear areas, and protects our troops and equipment from enemy weapons and sensors. Without these vital services, Army combat forces could not accomplish their mission of delivering decisive firepower at critical points of the battle.

The preceding article was prepared by key personnel at the U.S. Army Mobility Equipment Research and Development Command.

Army Missile Lab Cites Benefits of Existing Technology Applications

It's a straight shot south for 45 miles down Interstate 5 from the Seattle/Tacoma Airport to Fort Lewis, WA, a route increasingly familiar to Army missile engineers.

There are people at the Army Missile Command, Redstone Arsenal, AL (MICOM) convinced that Interstate 5 is a road the Army missile program must take because at Fort Lewis the 9th Infantry Division is in the process of testing and fielding the Army's new light infantry division. One of the people who believes that is MICOM Commander MG Robert L. Moore. He has directed an all-out effort to support the 9th Infantry.

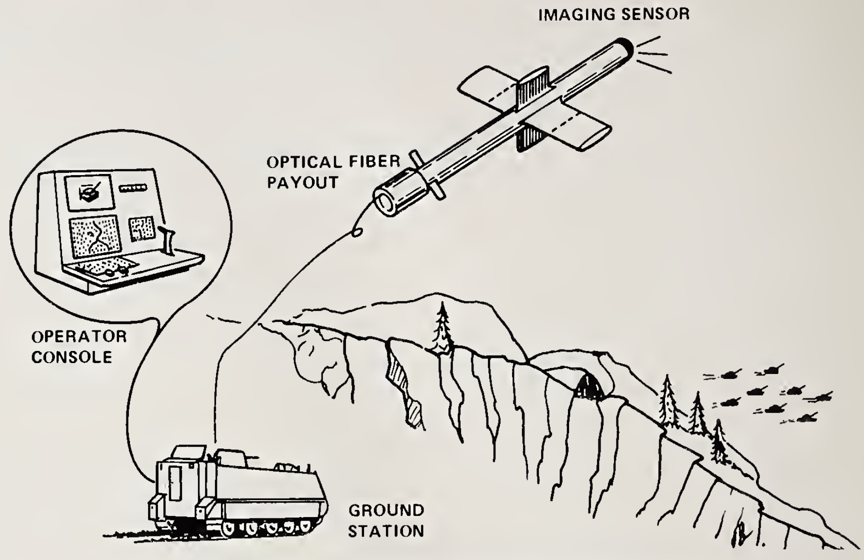
Dr. William McCorkle, MICOM technical director and director of MICOM's Army Missile Laboratory, also shares his commander's conviction that if available missile technology can be used to help the 9th Infantry and other Army combat elements as well, the 1,200 soldiers and civilian scientists, engineers and support personnel in the Army Missile Lab know how to do it.

In contrast to the early days of Army missiles when knowing how to do something usually meant developing new technology, Dr. McCorkle and his staff believe today's primary challenge lies not in invention but utilization, in choosing existing technology to get the most effective, affordable solutions to the Army's critical needs.

Such choices must be made in close cooperation with the Missile Lab's only customer, the American soldier, more properly with those who define the soldier's needs to the people in the lab charged with meeting them. The business of defining needs, MICOM leaves to "the user." One thread that runs through the long history of Army missile R&D, managed at Redstone Arsenal, is a maturing partnership between the Missile Lab and the user.

It is no accident, for example, that the lab's Advanced Systems Concepts Office, responsible for long-range weapon system planning, is also its element charged directly with working with the user.

User concerns are shaped by a certain urgency. When war occurs, it must be fought with available weapons. Therefore, MICOM's lab looks first to solve user problems by improving existing missile and rocket systems, or finding new ways to use available weapons before beginning lengthy and costly new R&D programs.



FIBER OPTIC Guidance System Concept

An R&D organization focusing on high-pay-off technology and a fairly rapid return on investment makes some people nervous. Their concern is that MICOM may be going for immediate payoff to the detriment of building the technology that will be needed for weapon systems in the future. In McCorkle's view, that concern is not well founded. Shortly after taking over direction of the Missile Lab in 1980, he told an interviewer: "I have found in over 20 years in this business that working on immediate, critical problems tends to produce about as much new technology as broader brush efforts. Our most important priority in the lab must be striking a proper balance between immediate payoff and longer term building of the technology base."

Translated into one specific example, that means the Army Missile Lab at Redstone is a place where one team works to find ways to some day fight with beams of light, while right down the hall another group is assembling a prototype towed quad mount for the shoulder-fired Stinger guided missile.

The lab uses matrix management techniques to integrate technology base and system support efforts under the guidance of associate directors for both technology and systems. Managing about $250 million annually in technology base and project manager (customer) funding, the lab has DARCOM lead responsibility for guidance and control technology and high-energy lasers.

Strong user interface is provided by the Advanced Systems Concepts Office, also responsible for long-range weapons systems planning. Technology base projects are executed in functional directorates responsible for research, sensors, guidance and control, simulation and aerodynamics, propulsion, structures, and high-energy lasers. The Systems Development Office manages projects transitioning into systems advanced development. The laboratory also has a small office dedicated to executing research programs assigned to MICOM by the Defense Advanced Projects Agency, such as Assault Breaker.

As in most military laboratories, what is new at MICOM is usually what is most classified. However, the following paragraphs will provide a brief overview of some of the key programs at the Army Missile Lab.

In the early 1960's, laboratory engineers conceived the idea of a pulsed, low-energy beam to provide precision guidance for explosive munitions. The same concept, with improved technology, has found application in MICOM's Hellfire missile now entering production. MICOM's technical support has also contributed to the successful application of terminal homing technology to the Copperhead, 155mm terminally guided artillery projectile.

A major example of MICOM's belief that operational weapons can be kept in service by improving them as technology becomes available is seen in the laboratory's support to the Hawk air defense missile. In the early 1970's, the

missile experienced catastrophic structural failure during firing tests. MICOM efforts led to both airframe and autopilot modifications, a permanent fix that was a critical step toward fielding a successful Improved Hawk.

More recently, the laboratory conceived a low-altitude simultaneous Hawk engagement concept which resulted in a dramatic increase in Hawk firepower. The entire development—from concept through simulation and flight verification—took only five months, and will become operational—as part of the Phase III Hawk product improvement program.

Viper, the Army's new lightweight, unguided anti-tank rocket now entering production, is an outgrowth of a challenging in-house demonstration program conducted in the laboratory during the early-to-mid 1970's. Laboratory engineers developed a new, high-performance carborane propellant, a lightweight, filamentwound fiberglass motor case and launch tube superior to equivalent steel products.

The Army has long considered the elimination of rocket motor smoke an important goal. Since 1973, laboratory engineers have worked to develop a high-performance, minimum-signature propellant. Their efforts led to the successful development of a now in production, "smokeless" rocket motor for the Chapparal air defense guided missile.

Recently, this high performance minimum signature propulsion technology has been extended for potential use in Hellfire. It will give missile firing helicopters a better chance of survival, and also improve missile effectiveness.

The MICOM laboratory uses integrated technology demonstrations to evaluate system level performance issues and to

CONCEPTUAL Laser Weapon System

reduce the risk of transitioning technology into subsequent development. Some recent examples are described below.

• Integration of optical and magnetic target sensing, coupled with a self-forging fragment warhead, has proven the ability to defeat future enemy tanks by attacking through lighter-top armor rather than frontal armor. Sensors, guidance, propulsion and aeroballistics technologies were integrated with the self-forging fragment warhead in a joint effort with ARRADCOM.

• Kinetic energy penetrators show great promise for defeating tanks. The Missile Laboratory is developing two concepts which use kinetic energy kill. In the first, the laboratory acted as system integrator to conduct the world's first successful flight test of a solid propellant, hypervelocity rocket/ramjet. In the second concept, the first phase of a program to demonstrate the potential armor kill capability with a single penetrator kinetic energy-free rocket was successfully concluded.

• The feasibility of using fiber optics guidance for missiles in close combat was established with a 3-kilometer flight test which demonstrated payout of a high strength fiber from a missile and simultaneous 2-way data transmission via a single fiber. The optical fiber was developed by CECOM in response to a MICOM requirement.

The fiber optics technique makes it possible to put most of the expensive guidance components in the launch station rather than the missile. Target acquisition prior to missile launch is not required, and a single operator can sequentially engage targets at high rate from full defilade positions at ranges of many kilometers.

Common to all these efforts, is a dependence on the laboratory's simulation and test facilities.

Army Missile Laboratory facilities—some of the finest in the world—are equipped and staffed to study problems of propulsion, aerodynamics, guidance, structures, electronics, and lasers. Major effort is expended on evaluating possible alternative systems, subsystems, and components. Many of these facilities are extremely versatile, capable of evaluating many types of systems and of carrying such evaluation from exploratory development through advanced development, and into engineering development and even production.

MICOM's major investment in facilities is concentrated in two areas—the Advanced Simulation Center and the Test and Evaluation Directorate's facilities.

The primary purpose of the Advanced Simulation Center is to provide high-fidelity simulation support services to Army and other DOD missile programs. System simulation permits a relatively quick and inexpensive evaluation of proposed product improvements, the impact of new countermeasures, and the effectiveness of off-design applications, to name but a few important uses. Project managers soon learn the value of reliable system simulations in making management decisions.

Perhaps the most attractive aspect of the simulation center is its tremendous cost avoidance potential. For an initial investment of approximately $50 million, MICOM has saved literally hundreds of millions of dollars by substituting simulations for expensive flight tests.

The price tag for an actual Improved Hawk flight test, for example, is $750,000. Hundreds of hardware-in-the-loop simulated flights can be performed non-destructively on a prototype missile for that cost, covering and determining the entire performance envelope. Today, one of the principal objectives of an actual flight test is to validate the simulation, as opposed to defining the envelope.

The laboratory's test and evaluation facilities, in addition to providing primary test support for the Missile Command, are used to conduct customer tests for other commands, services, DOD agencies, and private industry, and have been used in the test and evaluation of every existing Army missile system and in support of the laboratory's extensive technology base efforts.

The laboratory's most vital assets are its 1,200 scientific, engineering and support personnel dedicated to the premise that weapon system effectiveness and readiness is the key to survivability on the modern battlefield. The unique people, talent, facilities and resources that are MICOM were recognized for excellence when the MICOM Missile Lab was named the Army's best laboratory for 1981. In concert with the Army's RD&A plans, MICOM and its laboratory will continue to develop and field the best missile technology, at an affordable cost.

The preceding article was prepared by key personnel at the U.S. Army Missile Command and the Army Missile Laboratory.

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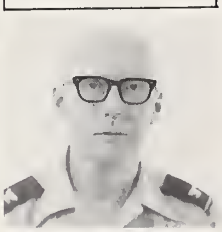


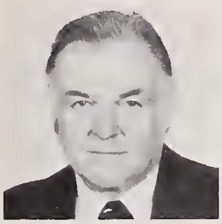
COL N. Cosby
Commander

ACRONYMS:

AARL—Army Aeromedical Research Laboratory
AIDR—Army Institute of Dental Research
AISR—Army Institute of Surgical Research
AMBRDL—Army Medical Bioengineering R&D Laboratory
AMMRC—Army Materials and Mechanics Research Center
AMRICD—Army Medical Research Institute of Chemical Defense
AMRIID—Army Medical Research Institute of Infectious Diseases
AMSAA—Army Materiel Systems Analysis Activity
ARI—Army Research Institute for the Behavioral and Social Sciences
ARIEM—Army Research Institute of Environmental Medicine
ARO—Army Research Office
ARRADCOM—Army Armament R&D Command
ASL—Atmospheric Sciences Laboratory
AVRADA—Avionics R&D Activity
AVRADCOM—Army Aviation R&D Command
BRL—Ballistic Research Laboratory
CECOM—Communications-Electronics Command
CERL—Construction Engineering Research Laboratory

atory Personnel

NLABS



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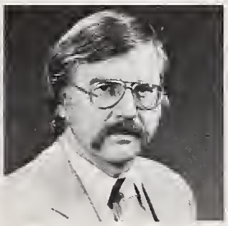

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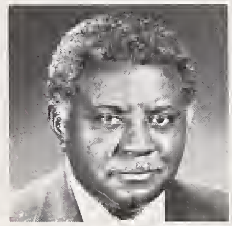

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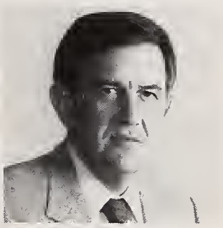

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COL B. Pruitt
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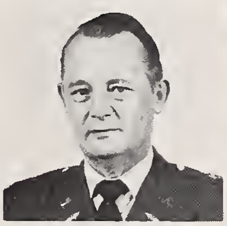

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AMBRDL

COL J. Albertson
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AMRIID

COL R. Barquist
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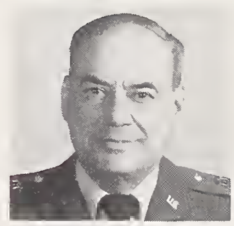
ARIEM



COL E. Pearlman
Cmdr./Tech Dir.

CRREL—Cold Regions Research and Engineering Laboratory
CSL—Chemical Systems Laboratory
CSTAL—Combat Surveillance and Target Acquisition Laboratory
CENTCOMS—Center for Communications Systems
CENTACS—Center for Tactical Computer Systems
ERADCOM—Electronics R&D Command
ETL—Engineer Topographic Laboratories
ET&DL—Electronics Technology & Devices Laboratory
EWL—Electronic Warfare Laboratory
FC&SCWSL—Fire Control & Small Caliber Weapon Systems Laboratory
FSTC—Foreign Science and Technology Center
HDL—Harry Diamond Laboratories
HEL—Human Engineering Laboratory
LAIR—Letterman Army Institute of Research
LCWSL—Large Caliber Weapon Systems Laboratory
MERADCOM—Mobility Equipment R&D Command
MIA—Missile Intelligence Agency
MICOM—Missile Command
NLABS—Natick R&D Laboratories
NV&EOL—Night Vision & Electro-Optics Laboratory
OCE—Office, Chief of Engineers
ODCSPER—Office, Deputy Chief of Staff for Personnel
RTL—Research and Technology Laboratories
SWL—Signals Warfare Laboratory
TACOM—Tank-Automotive Command
TECOM—Test and Evaluation Command
WES—Waterways Experiment Station
WRAIR—Walter Reed Army Institute of Research

Tank Automotive Command (TACOM)...
Programs Geared Toward an Effective Army Fleet

By TACOM Technical Director
Dr. Ernest N. Petrick

If it isn't carried on a soldier's back and it isn't an aircraft, then odds are that the U.S. Army Tank-Automative Command, (TACOM) Warren, MI, is involved. As the Army's ground mobility provider, TACOM has cradle to grave responsibility for the bulk of the Army's multi-billion dollar investment in ground mobility systems.

The command also provides the mobility capability for systems such as self-propelled artillery and missile launchers which are managed by other DARCOM commands. In FY 1982, TACOM will expend 12 percent of the Army's budget on executing its ground mobility responsibilities.

TACOM's ground mobility mission, in its broadest sense, is "TO KEEP THE ARMY'S FLEET EFFECTIVE"... technologically superior, supportable and ready. The last few years have seen a subtle but definite shift in the way this command approaches the research, development and acquisition aspects of this task. This shift is evident in both the tactical and combat vehicle areas.

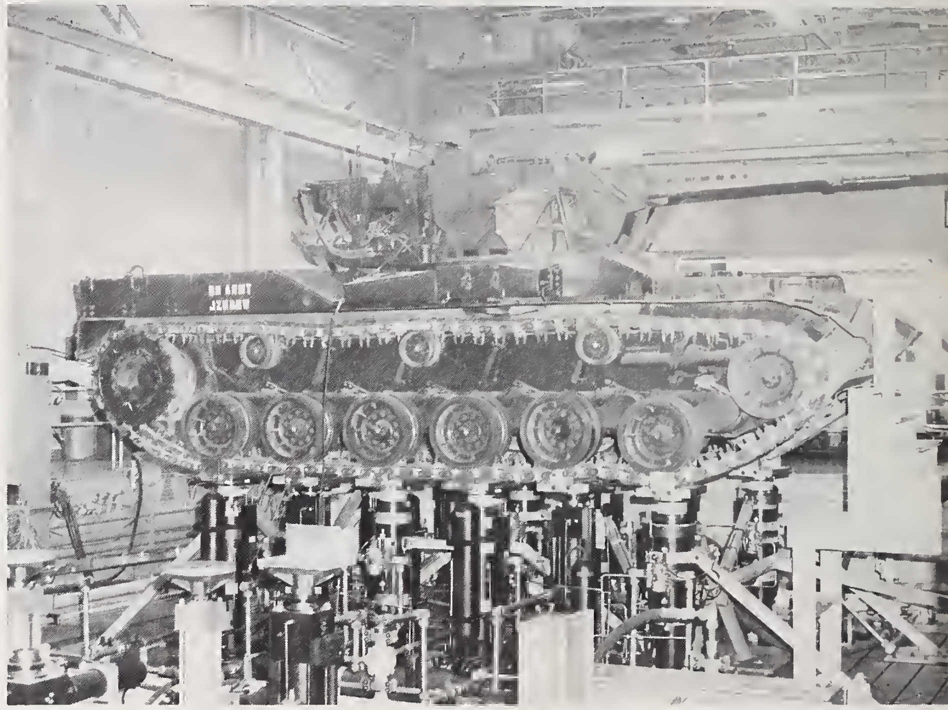
TACOM has substantially increased its reliance on vehicles and components developed for the commercial and industrial markets while concentrating on the adaption and integration of these to meet military requirements.

Whenever military requirements are met through this method, significant reductions in acquisition, operating and support costs are achievable. This acquisition strategy has permitted TACOM to concentrate its finite R&D resources on systems integration related tasks and on military unique materiel which cannot be bought or adapted "off-the-shelf."

The systems acquisition programs followed by TACOM clearly reflect the commitment to this strategy. Examples include the joint Army—USMC light armored vehicle project to test, evaluate and select from vehicles offered by the marketplace; and the high mobility multi-purpose wheeled vehicle.

The high mobility multi-wheeled vehicle entails a relatively small up front RDTE investment, $19.2M, and is focused to maximize the use of commercial components configured into a military design vehicle.

The TACOM R&D Center's greatest challenge in executing a marketplace acquisition strategy and constructing its R&D program has been to anticipate future requirements and pinpoint the right technology task investments.



HIMAG (High Mobility/Agility) 40-ton test-bed mounted in TACOM's Full-Scale Simulation Facility.

In the tactical vehicle area, the establishment of the Tactical Wheeled Vehicle Management Office has created a "fleet proponency" environment and has considerably enhanced the center's ability to identify requirements and pursue the marketplace strategy.

The combat vehicle arena, which receives the bulk of the command's RDTE funds—97 percent in FY 82, requires a "systems house" outlook and a continuous dialogue in order to anticipate requirements and achieve effective integration of the R&D efforts.

Consequently, TACOM has been increasingly active with the user community to coordinate an armored combat vehicle science and technology base development program.

Through seven science and technology action teams, ranging from the ARRADCOM chaired firepower team to the Communications Electronics Command's command, control and communications team, the tank-automotive community has a mechanism to insure its awareness of R&D activities which may impact on future armored combat vehicles.

In reviewing tech base activities, action teams assess the relative importance and funding sufficiency of tasks and identify technology gaps and opportunities. Action teams then report to a program advisory council, chaired by the TACOM commander. This approach has been increasingly effective in providing an agreed upon sense of direction.

Thus far, the highlight of the armored combat vehicle S&T program has been its contribution to the conduct of the future close combat vehicle study. This study was launched by TACOM in mid-1980 to take a hard look into future vehicle system concepts.

Action team members and user representatives were directly involved in structuring and overseeing the conduct of the future vehicle study and are active participants in the evaluation process. Four distinct contractor study teams were selected, and TRADOC gave each team an in-depth exposure to the evolving Air Land Battle 2000 concept.

Each team was also given extensive access to the best threat data available ... in fact, they had unprecedented access. The first iteration of these studies is now complete and the evaluation process, by both the user and development communities, has begun.

One of the first future vehicle study tasks was to examine the long-term trends which will impact on the environment in which these future ve-

hicles will fight. Four of the most significant trends identified were: that the lethality of threat weapons is growing; that the direction of attack from which a really first class threat can attack a combat vehicle is changing; that the location of the war restricts strategic mobility; and that there is a 24-hour day, all environment requirement.

Initial conclusions drawn from a very preliminary analysis of future close combat vehicle study results, have led to identification of certain design thrusts. These are increased lethality, increased agility/mobility, integrated battlefield interface, increased survivability, improved life support, reduced weight/bulk, and quantum RAM improvement. Findings of the armored combat vehicle S&T action teams and the design thrusts permit TACOM to discern future requirements and to structure its own technical base program.

A collateral influence in structuring TACOM's technical base has been a command commitment to capitalize on the independent R&D programs of DOD contractors.

Certain areas have been selected by TACOM for future emphasis. Mobility components will continue to receive emphasis. The overall thrust will be to increase mobility and agility, reduce component space claims and hence, weight penalties, improve fuel efficiency, and reduce life cycle costs.

The command has embarked on a major program to increase track life and reduce cost, weight and associated logistical burden. Use of operational analysis and computer aided design are also being exploited, and opportunities exist in the suspension area to improve ride and firing platform stability.

A very different approach to the combat vehicle power package is being pursued in the advanced integrated propulsion system program. Innovative integration of the engine, transmission, cooling, air filtration, and other subsystems also promise significantly reduced volume and weight penalties.

Adiabatic engine technology employs ceramics and other composite materials to permit replacement of engine cooling and lubrication systems. This promises dramatic reductions in volume and greatly improved fuel economy.

Armor, offering improved protection with reduced weight and volume, is another essential priority. Non-traditional survivability mechanisms will be required. Non-traditional survivability refers to actions taken prior to a vehicle being struck by a threat weapon.

In the past, survivability thinking was dominated by passive armors which concentrated solely against the terminal effect of the threat weapons. Stress is now placed on preventing that weapon from striking initially. Non-traditional survivability has two major branches, signature reduction and integrated threat warning and reaction.

Intensive use of electronics in vehicles leads to the new field of VETRONICS (for vehicle electronics). TACOM's objectives are to achieve more efficient integration of electrical and electronic systems and to gain real time integration with the electronic battlefield.

TACOM's approach is to implement a system to enable total integration by using computer controlled, bussed multiplexed data and power distribution with multifunction controls and interactive displays.

Vetronics is closely related to the Army's avionics experience and points towards an unprecedented level of interface between the aviation and ground mobility systems developers.

Robotics in vehicles is also on the horizon. There is a clear need to reduce crew size, and employ robotics to unburden crews. Further, there is a clear need to rethink life support systems to maximize crew effectiveness and survival. TACOM expects to devote considerable future effort in the application of robotics and new life support technologies.

Finally, systems concepts and demonstration remains a TACOM strength. The ability to produce detailed concept designs has been enhanced by computer aided design equipment. From these evaluations, critical issues can be determined for subsequent hardware evaluation in TACOM's Full Scale Simulation Facility and on systems level test beds.

DIVADS, 9mm Pistol Managers Get Impact Legion of Merit Awards

In recognition of outstanding managerial performance involving two of the Army's high visibility ongoing development-acquisition programs, the Division Air Defense (DIVADS) Gun System and the 9mm sidearm, DARCOM Commander GEN Donald R. Keith approved impact Legion of Merit awards, recently presented by LTG Robert J. Lunn (DCGMD), for COL Charles C. Adsit and LTC Anthony E. Bisantz.

Adsit, project manager of the DIVADS, was cited for his ability and skill in managing that system from 1 Oct 81 to 23 Mar 82, and for successfully guiding the program through the Army Systems Acquisition Review Council where formal production authority for the $5.3 billion investment phase of that program was granted.

Also cited was COL Adsit's skill in accepting the "challenge of Congress" and proving "that a major new weapon system can be developed on an accelerated schedule and with great savings to the American taxpayer."

LTC Bisantz's skill in managing the Army's program to acquire and test new sidearm candidates for the Department of Defense and other government agencies, was the basis for his award. Bisantz is responsible, said the citation, for organizing and directing the program. His careful and objective management of this extremely competitive, high interest and sensitive program, involving foreign as well as U.S. interests, was "directly responsible for insuring Army interests. . ." The citation praised his presentation of the program's test results and recommendations as guaranteeing the integrity of the DOD acquisition process.

2 Ballistic Lab Researchers Elected as Fellows

Dr. Phillip M. Howe and Dr. Edward M. Schmidt, both research supervisors at the U.S. Army's Ballistic Research Laboratory, Aberdeen Proving Ground, MD, have been elected as BRL Fellows.

An honorary group which currently has 24 members, the BRL Fellowship was established in 1972 by Dr. R.J. Eichelberger, BRL director, to recognize outstanding scientific and engineering achievements.

Dr. Howe, who is chief of BRL's Explosive Effects Branch, works with high explosives in the field of munition vulnerability and is engaged in projects. related to safe transport of munitions in railroad cars. He holds several patents and was a 1979 recipient of an Army R&D Achievement Award.

Dr. Schmidt, an aerospace engineer, is chief of fluid physics research in BRL's Launch and Flight Division. His research is primarily in the area of muzzle blast overpressures, relative to noise and recoil effects of weapons. Additionally, he holds four U.S. patents and received a 1980 Army R&D Achievement Award.

Test & Evaluation Command (TECOM)...

'Today's Tests Directed at Tomorrow's Defenses'

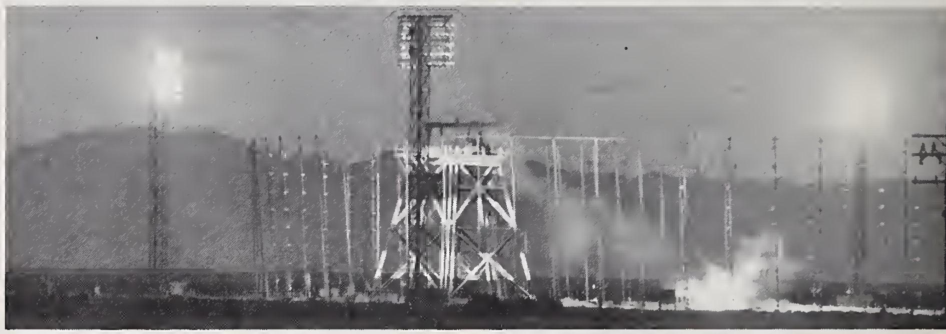
America's military arsenal, like the culture it defends, is constantly evolving. The U.S. Army Test and Evaluation Command helps usher in tomorrow's defense by serving as a gate through which future materiel must pass before deployment. Research, which opens paths into the future and improved science, is inherent in test and evaluation. TECOM often asks, "Is there a better way?"

Methodology investigation, a type of research, serves to improve test methods. Specifically, TECOM seeks more efficient and less expensive methods with which to perform software, environmental and simulation testing. The challenge is to achieve the above at a time of fiscal restraint and critical levels of natural resources.

TECOM tests at nine installations in the U.S. and the Republic of Panama, with direction and guidance coming from the headquarters at Aberdeen Proving Ground, MD, to form a cohesive program of methodology investigations. The element responsible for this is the Methodology Improvement Directorate, the name of which underscores the constant goal of making tomorrow's methods better.

Another TECOM endeavor addresses operational aspects and improvements in instrumentation equipment, the chief tools of testing.

Instrumentation yields critical feedback by recording performance, by transmitting data to assembly points and by blending it into test results. This effort is critical. For example, long-range missile shots, with elaborate preparations, are postponed if instrumentation is unable to record, transmit and assemble important data.



EXPLODING artillery shell illuminates tower grid during engineering tests of XM685, 155mm projectile, at Dugway Proving Ground, UT.

TECOM engineers scrutinize each test for the amount of data it can provide. They proceed only when certain that they will gain enough feedback to study a system thoroughly.

Instrumentation probably started with an individual performing a visual inspection, writing down data and summarizing it for analysis. Improved technology sophisticated the process. Today, much instrumentation is automated. Electromagnetic, optical, mechanical, and other sensors measure performance, and telemetry transmits it to computers for integration with other data and assembly into the performance picture.

Generally, all this is accomplished in real-time, which means data are available to observers as events occur, rather than after the test. For example, monitor screens display refined data about as instantaneously as a live television broadcast appears on your television screen. This capability enables TECOM to make alterations during testing, and it is particularly important for range safety.

What can future instrumentation do for an encore? Look for even more automation. Instrumentation is required to do more sophisticated testing with fewer assets. The solution, officials believe, lies in streamlining instrumentation tools, such as by working the data recording, transmission and integration devices into closer harmony, thereby reducing test time.

Instrumentation cannot wait until tomorrow to test tomorrow's weaponry and military equipment. Already, instrumentation is being developed for tracking and recording data from multiple targets in consonance with the latest developments for missiles with multiple warheads. Currently, a computer-driven drone formation control system can fly up to six full-scale drone aircraft in close formation. The drone aircraft represented the foreign threat during tests requiring three patriot missiles to engage three aircraft.

Test policies such as the Single Integrated Development Test Cycle (SIDTC) have reduced time alloted for developing instrumentation and applying it to new systems. Prior to SIDTC, testing was sequential and instrumentation for each phase could be postponed, if other priorities dictated, until a particular phase was scheduled to begin. Under SIDTC, several phases start at once, and most instrumentation must be ready from the outset.

Other developments are on the horizon: advanced technology instrumentation systems to identify height-of-

SIG-D (Simplified Inertial Guidance-Demonstration) missile emerges from a climatic chamber prior to launching at White Sands Missile Range (WSMR), NM. The SIG-D test program is being carried out at WSMR by the U.S. Army TECOM, which tests proposed Army materiel at nine installations and activities.

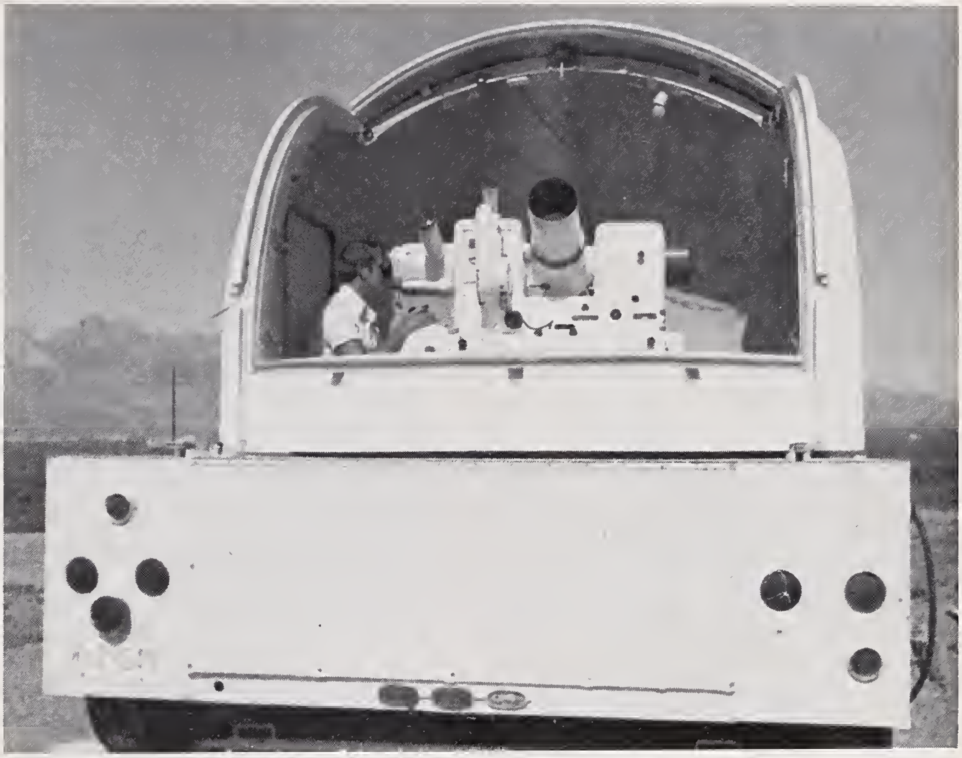
burst and impact locations of projectiles; low-altitude tracking, high-energy and other laser systems testing; improvements in ballistic testing capability; and less labor-intensive instrumentation for lower operational costs.

Lasers are a fertile area for development of advanced instrumentation. Programs are underway to provide the latest instrumentation technology in lasers for multi-lateration, tracking of non-cooperative missiles and detection of dynamic motion of projectiles in space.

Laser automated tracking systems are also enroute to the future instrumentation inventory. The system will provide precise real-time space position data of aircraft and other flight vehicles at less cost than current systems. It is self-contained in a transportable van from which an infrared laser is beamed to a reflector mounted on another vehicle up to 20 miles away. The beam is reflected back to a receiver in the van which analyzes the second vehicle's position for changes in azimuth, elevation and range.

Three of these systems are used at Yuma Proving Ground, AZ, for calibration tests of a satellite navigation system. White Sands Missile Range, NM, uses two of the systems to measure trajectory parameters of various flight vehicles and ordnance. A high-energy laser system test facility is under construction at White Sands to test DOD laser weapons engaging moving targets. This facility will reduce test costs by consolidating the expensive support equipment to one site.

A major problem facing the Army and other services is the interoperability of automated battlefield systems. These command, control, communications, and intelligence systems have not been tested under full load conditions as interoperating systems in the battlefield electronic environment. MAINSITE is a new concept to be installed at the Army Electronics Proving Ground which will rely on computers and electromagnetic simulations to create the battlefield system interaction under load conditions and electronic environment needed to test this new generation of weapons systems.



MCM Mobile Contraves Cinetheodolite, optical tracking instrument, provides azimuth, elevation and angular data during target testing at White Sands Missile Range, NM.

CAMOUFLAGE nets cover Hawk radar and related equipment, during a U.S. Army Test and Evaluation Command test at White Sands Missile Range, NM.

Another battlefield environment is being created to counter terminally guided weapons. Smoke can interfere with the current generation of imaging systems and new smokes are being developed to counter the new infrared seeker systems.

TECOM is developing a lesser infrared detection and ranging tracking system to give the three-dimensional characteristics of moving clouds. Lastly, many weapons on the drawing boards will use millimeter wavelength radiation to penetrate smoke and battlefield dust. Here too, instrumentation is being developed to measure millimeter wavelength system performance.

Many of the multiple munition systems are intended to engage multiple tank targets. The drone formation control system has been modified to provide remote control of 10 M47 tanks which can be programed to represent a convoy and battlefield formations.

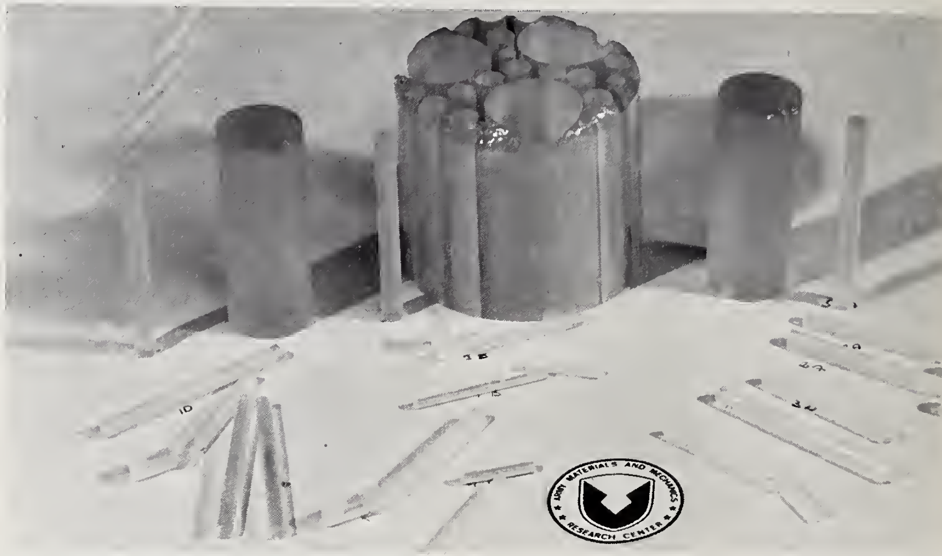
Secure telemetry is being acquired to assure that the data transmitted from instrumentation sensors to the analysis are are not intercepted by an unfriendly agent. All of this adds to the cost and the complexity of test instrumentation.

In addition, many new methodologies for testing in the natural environment are evolving. Time-consuming and costly, the environmental test effort is heavily involved in re-evaluating the practicality of open-air testing. Chamber testing, simulating a particular environment within a man-made structure, can replace much natural environment testing. TECOM envisions more attempts to improve the quality of chamber testing.

Whenever you strike into uncharted areas, as TECOM often does, you can expect some surprises. Better for them to happen in a test environment than on the battlefield. That is TECOM's job: to make sure the soldier in combat gets what he expects from his materiel. To do this, TECOM tests tomorrow's defense today.

The preceding article was prepared by key personnel at the U.S. Army Test and Evaluation Command.

Army Materials & Mechanics Research Center (AMMRC)...
'Better Materials for Tomorrow's Army'



LASER RODS manufactured from world's largest ND: YAG single crystal.

A one letter difference in the words material and materiel results in a change in meaning that summarizes the relationship between the Army Materials and Mechanics Research Center (AMMRC) and its parent command the Army Materiel Development and Readiness Command (DARCOM). The transition of raw materials into Army equipment has been the concern of AMMRC and its forerunner, the Watertown Arsenal, since 1816; from cast iron, leather and wood to the high strength metals, ceramics and composites required for the high technology battlefield.

Today's AMMRC is the modern materials research and development activity responsible for managing and conducting the DARCOM research and exploratory development program in materials and solid mechanics. Its charters as lead laboratory for materials, solid mechanics, and materials testing technology require AMMRC to possess the in-house technical expertise and facilities to perform R&D projects ranging from the synthesis of new and improved materials and designs to the prototype manufacturing of components for Army Weapons systems.

In addition to its management of the materials research program, AMMRC serves the Army in several other capacities. It develops both destructive and nondestructive methods of materials testing and manages the materials testing technology program for DARCOM.

As an integral part of its mission, AMMRC conducts the DARCOM nondestructive testing training certification program and provides this type testing field support throughout the DOD. AMMRC is also responsible for managing and directing the Army portion of the defense standards and specifications program for materials.

The Ballistic Missile Defense Materials Program Office at AMMRC is a special project organization executing high priority R&D programs concerned with the development of materials for advanced strategic and tactical missiles. Key developments are optical sensor system materials, hardening of radar components, advanced structural materials, propulsion system materials, and thermal protection materials.

Through its efforts, AMMRC addresses the major materials issues facing the Army today. Worldwide operational capability for the Army requires an increase in performance, durability and survivability of Army materiel and the capability to produce that materiel in sufficient quantities at reasonable cost.

Logistical burdens in a fuel-short environment dictate the development of new lightweight materials concepts, and the integrated battlefield of the future will expose Army materials to the threat of chemical, nuclear and laser attack, as well as improved conventional weapons.

In addressing these problems, AMMRC has expanded its scope over the years to include a wide range of new materials. Early emphasis on metals development continues today with projects in the armor and armor-penetrating materials areas, research into materials processing and net-shape forming techniques, corrosion susceptibility, and surface-hardening processes for gear and bearing applications.

Research in ceramics has led to many new applications for these materials: silicon nitride components for heat engines, fused silica radomes, laser rods for rangefinders, and photochromic glass for laser protection. Ceramics are also finding increased use in combination with other materials for lightweight armor applications.

Continued development of metal and organic matrix composites will assure the availability of lightweight high performance materiel for utilization by rapid deployment forces where light-weight and high mobility will be key factors in the logistics of future combat.

Organic materials such as adhesives, elastomers and polymers are also receiving increased attention with research directed toward such applications as fuel-handling equipment, materials and coatings for protection against chemical agents, fire-resistant materials and wear-resistant track pads for combat vehicles.

Future plans call for increased emphasis in the areas of materials processing technology to insure quantity production of materials at reasonable cost, an advanced development effort in support of specifications and standards and the establishment of an expanded elastomer/rubber capability.

Examples of the utilization of advanced materials fostered by AMMRC include: a polyphospazene rubber air plenum seal in the Abrams tank, a transparent blast shield for the Apache attack helicopter, spall suppression liners for the M113 armored personnel carrier, composite rotor blades for the Chinook cargo helicopter, and a cast titanium impeller for the T62 auxillary power unit.

Army R&D achievement awards have been presented in recent years to AMMRC staff members for work in such areas as laser resistance of tungsten-bearing resins, development of nitrogen-stabilized cubic aluminum oxide and characterization of resins for composite materials.

AMMRC's research program is planned

within seven major thrust areas: aircraft, armament, combat and tactical vehicles, missiles, mobility equipment, logistics, and personnel support. Among primary guidance sources used in formulating and prioritizing the program are the Army long-range plan, Training and Doctorine Command priorities and mission area analyses, and the materials needs of the DARCOM major subordinate commands and program managers.

Research projects are also carried out by three in-house laboratories, organized along technology lines.

Activities of the Metals and Ceramics Laboratory include state-of-the-art technology in metal matrix composites for bridging, advanced armor materials, materials processing, penetrator materials, fragmentation materials, advanced gun tube materials, corrosion and stress corrosion cracking, rapid solidification technology, radomes and multi-mode windows, ceramics for laser rods and high-energy laser protection, and ceramics for heat engines.

The Organic Materials Laboratory places primary emphasis on materials processing and characterization, advanced armor materials, materials for lightweight vehicles, organic matrix composites, CBR protective materials, polymers and elastomers for track components, fire-resistant materials, laser hardening and adhesive bonding.

Additionally, the Mechanics and Engineering Laboratory concentrates on shock-impact mechanics, penetration mechanics, fragmentation mechanics, structural integrity and reliability, nondestructive evaluation, life prediction/reliability mechanics, mechanics of HEL/structures interaction, dynamic deformation and fracture, materials testing technology, materials specifications and standards, and mechanics of advanced materials.

Vital statistics for AMMRC include an FY 82 budget of over $37 million, a manpower strength of 572 civilians and 13 military of which 257 are scientific and technical personnel, and a total of 382,000 square feet of laboratory space.

These assets are combined to conduct priority technical programs at the leading edge of materials technology, and through close coordination within the entire DARCOM community, AMMRC is able to fulfill its mission of assisting the Army in developing and maintaining the finest in modern weapon systems.

The preceding article was prepared by key personnel at the U.S. Army Materials and Mechanics Research Center.

Reduced Gold Use in Electronics May Lead to Large Cost Savings

Electronic engineers at the Defense Electronics Supply Center, Dayton, OH, recently completed the initial phase of a study on ways to reduce use of gold in electronic connector contacts. Promising results have been reported.

According to Mr. Richard Schade, project engineer for connectors in the DESC Directorate of Engineering Standardization, the study showed that gold use in connectors can be reduced by two-thirds or more by limiting the area to which gold plating is applied.

"The cost savings are tremendous, and the degradation to the system is nil," said Schade. He notes that one inviolate rule of the study is that requirements of the connectors, which are used in military systems, must not be lowered.

"The key to what we did is that our proposed reduction in the gold area did not degrade the performance of contact or connector," said Schade. We developed a porosity test to validate the effectiveness of the plating," he added. The test was devised by Mr. Max Peel of Texas Instruments, and is now being implemented in new military specifications and standards for connectors.

The study identified several dozen military specifications that should be reviewed for inclusion of gold localization techniques. Two military specifications, one Navy and one Air Force, are now being changed to accommodate the gold reduction technique. It will be expanded to additional connector documents as they are revised.

The reduction in gold use is possible because, according to the study, in many cases it has been used in both non-critical and critical areas. When gold prices skyrocketed, it became critical to reduce the amount of gold used. Plating a reduced area is practical because the vast majority of current manufacturers have the in-house capability to do so right now.

The gold reduction technique is applicable to all kinds and shapes of connectors, and also can be applied to many other kinds of electronic components, such as relays, integrated circuits and switches, which have similar plating characteristics, said Schade.

The gold reduction study got underway in February 1980, and is entering its second phase, which will consist of examining the possibility of reducing the thickness of the gold plating in connector contacts. Schade estimates that phase two will require one to two years to complete, as will the third phase, which will attempt to identify alternate metals for use as plating in connector contacts.

Gold has traditionally been used in electrical contacts because it has excellent electrical conductivity. It does not easily react with other substances; more to the point, it does not react with the atmosphere to form oxide or tarnish films on its surface. No other metal is as completely free of oxide films.

This characteristic makes gold desirable for use in electrical contacts, because oxide films are contact insulators—they prevent the current flow that is a contact's job to produce. Even an invisible film one microinch (one millionth of an inch) in size can increase electrical resistance to thousands of times the maximum allowable.

Gold surfaces provide clean metal-to-metal contact at the interface of connectors, even at the lowest contact pressure, and under virtually all environmental conditions. Therefore, they are desirable for use in contacts when the highest possible reliability is needed, as is the case in military systems. However, according to the DESC study, the use of gold can be reduced without sacrificing the effectiveness of the contacts.

DARCOM Revises ILS Handbook

Publication of a revised and updated *Integrated Logistic Support Primer, DARCOM Handbook 700-1.1-81,* has been announced by the U.S. Army DARCOM Materiel Readiness Support Activity.

A pocket-sized ILS reference guide, the short booklet is designed to provide Army personnel with a comprehensive overview of basic ILS policy. Revision of the booklet was prompted by numerous recent changes in the Army's ILS policy, including new reviewing and reporting requirements.

Copies of the booklet are available from the Commander, U.S. Army DARCOM Materiel Readiness Support Activity, ATTN: DRXMD-EI, Lexington, KY 40511. Additional information may also be obtained by calling Autovon 745-3393 or commercial (606) 293-4154.

AMSAA Serves Key Role in Assessing Weapons Effectiveness

By Mr. Keith A. Myers
Director, U.S. Army Materiel Systems Analysis Activity

Will the new weapon system work the way it was intended, when it's supposed to, and can it be supported in the field? To provide answers to these vital questions and others is the job of AMSAA—the U.S. Army Materiel Systems Analysis Activity, Aberdeen Proving Ground (APG), MD.

AMSAA's origins go back to 1945 when a small weapon effectiveness evaluation group was formed in the Ballistic Research Laboratory at Aberdeen Proving Ground, and over the years this weapon effectiveness evaluation capability grew and expanded to other materiel areas. Then, in 1968, AMSAA became a separate activity with Dr. Joe Sperrazza as its first director and it continued to grow to its present size and structure (Fig. 1). The author took over as director in July 1981.

A significant part of AMSAA's effort is devoted to providing item/system level performance and effectiveness data as input to studies conducted by TRADOC, the Concepts Analysis Agency, and others involved in cost and operational effectiveness anslyses or similar large studies involving Army materiel systems.

As the Army has demanded increasing capabilities through better equipment for a variety of combat environments, the assessment of equipment performance and effectiveness has grown in complexity. This has led to a continuing need to upgrade our evaluation capabilities and to consider more realistic representations of the modern battlefield environments.

AMSAA develops, maintains and uses a full range of models from single systems through small unit and division level to support its analyses. Since no analysis is better than the input upon which it is based, the development of an adequate data base for systems analysis is a significant effort for AMSAA.

In response to recommendations arising from the early 1970's Army Materiel Acquisition Review Committee, AMSAA was assigned the responsibility for the test design and independent evaluation of the development tests of all major, designated non-major and selected other materiel systems as well as product improvements to them. This quickly became one of AMSAA's major efforts, with as many as 60 such test and evaluation programs active at one time.

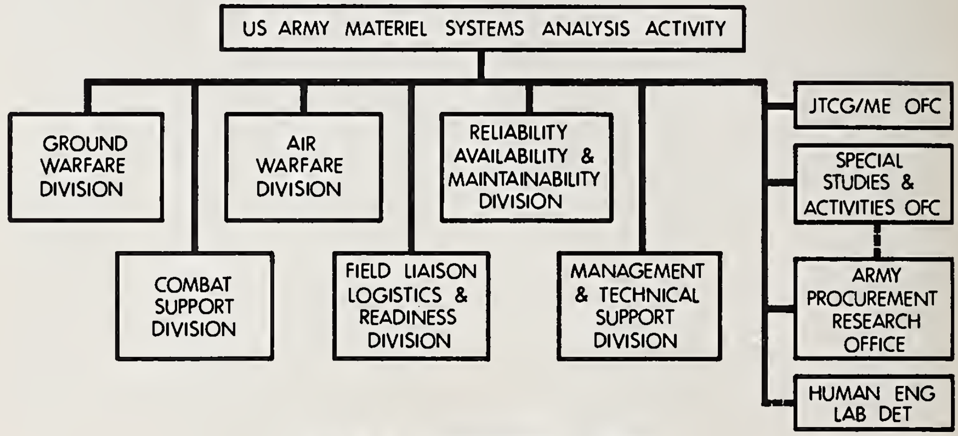


Figure 1. Organization Chart.

In the execution of this mission, AMSAA has coupled its expertise in test design and analysis with its systems simulation capability to evaluate critical system issues. Issues addressed range from system effectiveness to system maintainability and supportability.

Another very significant element of AMSAA's mission is its field liaison program. Teams are sent to visit various field units, all over the world, to discuss equipment problems. These visits reinforce DARCOM's commitment to the soldier and provide an interface with the DARCOM major subordinate commands. While these teams are composed primarily of AMSAA personnel, engineers and other specialists from the commands also participate to see first hand their equipment in the field environment, answer questions and resolve problems on the spot.

Although it began with an R&D orientation to system performance and effectiveness, AMSAA has developed and expanded its capability to support other elements of DARCOM. Major emphasis was given to assessing maintenance, supply and other aspects of readiness as AMSAA began to address spare parts stockage for repair of combat damage, time goals for air lines of communication, and other issues.

AMSAA also has a world-wide stockpile surveillance mission to provide DARCOM an overview of the reliability of nuclear and non-nuclear ammunition, missiles and other materiel deployed or stockpiled. To supplement these capabilities, the Inventory Research Office, the Logistics Studies Office, and the Procurement Research Office were assigned to AMSAA in the fall of 1981.

AMSAA is also designated the lead DARCOM activity for survivability and the DARCOM center for reliability, availability and maintainability methodology. Most recently, AMSAA was assigned the DARCOM battlefield systems integration mission with the disestablishment of that staff at HQ DARCOM under RESHAPE.

Involvement in programs with the other services and the analysis establishments of other nations is also part of AMSAA's activity. The director of AMSAA is the chairman of the Joint Technical Coordinating Group for Munitions Effectiveness, a joint service working group established to publish standardized munitions effectiveness data on U.S. weapons. These joint munitions effectiveness manuals are developed by the individual services under DOD sponsorship with program coordination by a small staff at AMSAA.

The director is also the U.S. national leader and executive chairman of Panel W-6 on generic weapons system effectiveness of the technical cooperation program, with representatives from the U.S., Canada, Australia, New Zealand and the United Kingdom.

AMSAA has an authorized strength of 449 civilians and 32 military personnel. More than half of the technical staff are operations research analysts with the other half divided among the basic sciences and engineering fields. The FY 82 budget is $28.6 million—$22.5 million RDT&E, $4.8 million OMA, and $1.3 million in customer funds. Yes AMSAA does provide answers to the vital questions leading to better Army equipment.

ARO Serves Many Needs as Multi-Disciplined Agency

The objective of the Army Research Office, known popularly as "ARO," is to engage the nation's finest scientific and engineering talent in research which is expected to have an impact on military technology. The ARO is located in the Research Triangle Park, NC, with some 40 other research and technology organizations and in close proximity to three major academic institutions.

The ultimate goal in the production of scientific information is to maintain our technological superiority and to increase lead time over potential adversaries. This job is done through approximately 750 active contracts with research laboratories within universities, industry and not-for-profit research organizations throughout the nation.

The scope of ARO's extramural research program is the largest of any of the elements in the Army R&D community, involving eight scientific disciplines: chemistry, biological sciences, electronics, engineering, geosciences, material sciences, mathematics and physics.

Contract decisions are based on a thorough system of technical peer review, using experts from within and outside of the Army to assure both scientific quality as well as Army relevancy. This entire effort is managed by a group of approximately 30 professional scientists, most of whom are personally active in research and technology. Dr. Hermann Robl, an internationally recognized physicist, has been technical director since 1975. He has also recently served as acting director until the installation, in July, of Dr. Robert E. Weigle, former technical director of the Army Armament R&D Command.

In the recent past, the ARO scientific program has been oriented toward Army objectives including chemical and biological defense, microelectronics, adverse weather, gun propulsion, surveillance and target acquisition, advanced materials, armor and antiarmor, directed energy, adverse terrain, mobility and installation energy, fire control and embedded computer software, explosives and shock phenomena, vertical lift, manufacturing technology, and human factors.

The chemical and biological defense thrust, for example, involves research in six scientific disciplines and concerns specific problems in chemical agent detection, decontamination, protective materials, atmospheric phenomena, and biological agent detection and identification.

Vertical lift technology represents a unique DOD investment in the development of national academic centers in rotorcraft technology. These centers will perform research in a wide spectrum of subjects relevant to rotorcraft technology and will develop a cadre of highly qualified engineers, scientists, and Army aviation officers.

The ARO methodology in selecting its research investments is very much like any other sound business investment decision, namely, to select investigators with outstanding "track records" in producing high quality and relevant research. In this regard, the Army takes pride in its support of many Nobel Laureates and recipients of other symbols of research recognition. For example, Dr. William Spicer, a long-time ARO contractor, was recognized as the 1981 scientist of the year by the *Industrial R&D Magazine*. Prof. H.C. Brown of Purdue University publicly praised the significant role that the Army Research Office played in his work on boron chemistry, for which he was recently awarded the Nobel Prize in chemistry. These research efforts are fundamental to night vision devices and propellant technologies, respectively.

Additionally, new young investigators with novel ideas for research are sought out and supported. The office is also known for its Junior Science and Humanities Symposia and fellowships for graduate students in critical research areas.

Accomplishments of the office in terms of contributions to the national scientific effort are impressive with several thousand reports being generated every year. The true significance of this effort, however, is measured in terms of hundreds of interactions between ARO researchers, the Army lab technologists and defense contractors. For example, models of the processing and electronic behavior of integrated circuits and devices, are widely used in the computer-aided design of military integrated circuits.

Research on hot gas erosion has led to the development of improved diagnostics and erosion-resistant coatings, and many alloys of rare-earth metals are now being used in Army systems which involve electromagnetic control and will be used for energy storage in the future.

New materials have been chemically synthesized, for example, boron derivatives for missile propellants and polyphosphazenes for high performance elastomer seals in helicopter applications. Methods have also been developed for predicting maximum lift of helicopter rotor airfoils and optimum metal forming processes for projectiles.

Major advances have been made in the techniques involving fast algorithms for application in fire control, image processing, filtering and guidance and control. Millimeter wave detectors, very near the fundamental limits of sensitivity, have been fabricated and demonstrated in planar configurations for high resolution imaging radar during obscured visibility.

Army Research Office personnel are very sensitive to the need for rapid transfer of scientific results to potential users. Typically, about 15 to 20 activities in technology transfer from the ARO program to Army laboratories or defense contractors are documented annually.

The Army Research Office contract program is carried out at a cost of slightly more than 55 million dollars annually by a staff of approximately 100, one-third of whom have advanced degrees in science and engineering. This core of the scientific and engineering staff of course, is greatly augmented by the estimated 1,000 to 2,000 technical reviews performed by scientists outside of the ARO in connection with its proposals.

The argument for performing research in the present climate of escalating system costs is stronger than ever. Research has the potential of providing dramatic reductions in cost and increased reliability such as in the transition from vacuum tube to solid-state electronics. At the same time, there is also the promise of totally unexpected, novel capabilities which may form the basis for new systems.

In research, a very small investment buys a great deal as compared to significant costs which occur when technology is being applied in system development. To a large extent, the enormous cost of present weapons systems and their lengthy development time is attributable to a lack of information which research must generate. This is the important role of the ARO.

The preceding article was prepared by key personnel at the U.S. Army Research Office.

Human Engineering Laboratory (HEL)...

Major Thrusts Determine Soldier/Equipment Performance

By HEL Director Dr. John D. Weisz

The U.S. Army Human Engineering Laboratory's (HEL) main interests have always been to research and determine the soldier's physical and mental performance and to help Army equipment designers achieve the optimum point where the soldier works best with the machine the Army provides for combat.

The Army is extremely concerned with achieving parity with the capabilities of our potential enemies. We're not as worried about quantity as we are with stepping up the quality of our current and future combat systems. Since its creation in 1951, at Aberdeen Proving Ground, MD, the HEL has strived to find the best working relationship between the soldier and the machine. That relationship must be achieved for the total materiel system to be effective in combat.

We must ''wring out'' every potential advantage to develop effective combat materiel, using the best technology we possess. Helping achieve this goal is what the HEL is all about.

The HEL conducts both laboratory and field experiments to accumulate and record data on soldier (both male and female) performance. Once the data are recorded, it is stored in HEL's Department of Defense-wide data bank, an information storage facility that handled over 18,000 foreign, industry, and in-house requests for technical information during FY 81. The bank contains information from many sources other than HEL. It holds a wealth of knowledge from universities, other DOD laboratories, and NATO.

The HEL has established detachment staffs at each of the DARCOM R&D Commands, whose members work daily with project managers and materiel designers at each location to make the flow of information and the development of systems move quicker and smoother.

The laboratory also provides field liaison offices at major TRADOC centers and schools, which close the loop in the materiel acquisition process; the liaison personnel become involved early on, assisting TRADOC in writing Letters of Agreement and Required Operational Capability documents. They make sure these documents do not ask the impossible of the soldier.

When the acquisition process reaches DARCOM level, HEL detachment members become involved with the designers and contractors to make sure the machine and the soldier's performance with it mesh intricately.

The HEL is required to complete an independent human factors study before the Army Systems Acquisition Review Council process begins. If the soldier is still experiencing problems working with the equipment, these obstacles must be overcome before an item or system is permitted to go on to the next phase of development.

The HEL has served as lead laboratory for several interesting research programs. It is the lead laboratory for human factors engineering with DARCOM, as well as the lead agency for Military Operations in Built-Up Areas. Most recently, the HEL was selected to serve as DARCOM's lead laboratory for robotics.

The HEL has been quite successful over the last few years as a quick-response organization for designing and demonstrating materiel concepts, many of which have already been fielded. Some of the fruitful accomplishments over the last 10 years include:

TOWCAP, or TOW Missile Cover From Artillery Projectiles or Fragments. It was HEL's responsibility to develop a protection device for the M113 TOW vehicle crew to keep them safe from artillery rounds and fragments. This vehicle normally has an open top. The first prototype was developed, produced, and provides the same amount of protection that the top of the regular M113 vehicle provides. When HEL completed its research, the project moved to the U.S. Army Natick R&D Lab and went into production; it was fielded in Europe in FY 79.

The Evasive Tank Target. HEL acted as the salesman, the designer and the fabrication crew for this project. Lab experts had to first sell the need for such a target, then design and construct the first prototype. HEL later provided 12 of the kits for the Operational Test and Evaluation Agency. The project then moved to the U.S. Army Tank-Automotive R&D Command, where more kits were fabricated and successfully used in a number of field tests.

NBC-protected, fire direction center vehicle, designed, fabricated and tested by HEL in 1981, is scheduled for joint-effort testing by HEL and the Chemical Systems Lab.

Precision Target Locator. HEL worked with the AAI Corp. on this project, designing and developing the first prototype. The GVS-5 laser rangefinder, encoders and associated electronic units were mounted on the equipment. The system was then interfaced with the Digital Message Device and the Fire Direction Center of conventional artillery systems. The project moved to the U.S. Army Missile Command.

Digital Weapon Fire Control Monitoring System. Once again, the HEL worked with the AAI Corp. to design and develop the first prototype, which was used and demonstrated in the HEL Battalion Artillery Test in 1981. TRADOC will be testing the system as a training device. This system has the potential for annual dollar savings in the hundreds or millions; the savings will come in the reduction of ammunitions and POL costs formerly used for training of artillery gun crews.

Integrated Helicopter Flight Control. Two HEL versions have been designed, fabricated and installed into an OH58 helicopter. After successful testing con-

ducted by the Army Engineering Flight Activity in February 1978, this project has led the field in developing a "fly-by-wire" integrated flight control concept.

Design of TOW Firing Bunkers in Korea. The HEL led a team of top DARCOM representatives to Korea for the formidable task of designing and testing a TOW firing bunker. After minor modifications, the HEL version was adopted. Construction has been completed and the bunkers are now in use by the Republic of Korea Army.

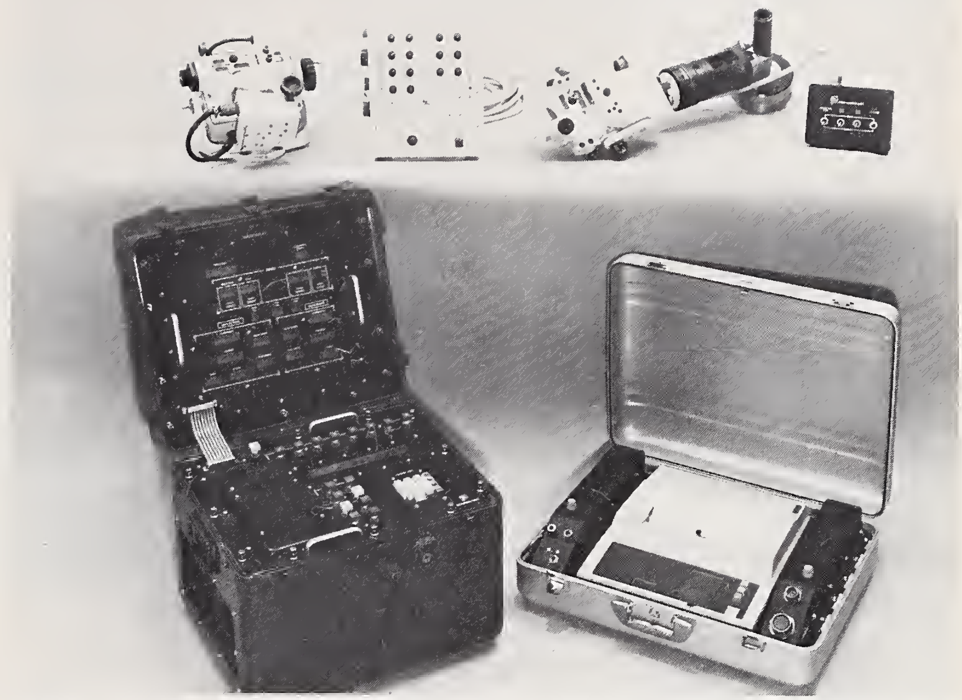
Integrated Training Documentation and Training Project. The HEL developed and sold a new training manual concept to TRADOC and DARCOM. Department of the Army approval for this, revised training documentation preparation and maintenance training on all new DARCOM development programs came in FY 78.

Military Operations in Built-Up Areas. DARCOM Headquarters asked the HEL to prepare a coordinated MOBA program and to staff it with personnel from the Berlin Brigade, TRADOC, Department of the Army, and all other DARCOM agencies. The HEL has finalized the project and presented it to the Deputy Chief of Staff for RDA for approval and funding. Meanwhile, work has begun on many of the 38 tasks in the composite program both at Aberdeen Proving Ground, MD, and Las Vegas, NV. A number of report results have been published, including a test of current generation radios in Havre de Grace, MD; Philadelphia, PA; and Boston, MA. A third DARCOM-TRADOC built-up area program has been developed and coordinated by the HEL; it has been submitted for approval and funding.

The HEL designed, fabricated and successfully tested the *First Artillery Ammunition Resupply Vehicle*, known as FASTV. FASTV is now in production, going directly from a demonstrator level into advanced development; production is now scheduled for deployment to Europe.

A one-of-its-kind, *NBC protected, Fire-direction Center Vehicle* was designed, fabricated and successfully tested by the HEL in 1982. More testing will be conducted on this vehicle in a joint effort by the HEL and the Chemical Systems Laboratory, U.S. Army Armament R&D Command.

It's clear that the HEL is responsible for a wide-ranging variety of research projects that have a significant impact on modern defense. The laboratory's capabilities range from exclusively providing supporting human factors engineering services to developing concept weapons systems, and conducting materiel design feasibility studies. Its quick design and development response to DARCOM and TRADOC has been proven many times.



Digital Weapon Fire Control Monitoring System, originally designed as a research tool, is now being considered as a means of training artillery gun crews, with an enormous reduction in ammunition and POL costs.

Very significantly, the HEL has served in a liaison role between TRADOC and DARCOM in the areas of target acquisition, communications, tactics and doctrine. This liaison role is especially pronounced in the field introduction of new materiel in the artillery area. As such, the laboratory is serving as a small, field-oriented, battlefield systems integration agency.

A strong working and coordination relationship has been fostered between the HEL and the Office of The Surgeon General. This relationship has served to provide early biomedical input to DARCOM development programs.

The Army is facing critical manpower and budget restraints. In the past few years it has become evident that automation is the key to future productivity. With this in mind, the HEL, as lead DARCOM agency, has begun a joint DARCOM-TRADOC project for the research and development of robotics. An executive steering-group from both major commands has been formed and a 5-year program is being developed.

An on-going HEL technical effort will exploit current technology in an effort to ease manpower requirements and to enhance operational performance. The first product of this effort will be a technology demonstration program that uses a robotic ammunition loader for the M110 Howitzer. Another robotics demonstration for ammunition handling at the ammunition supply point is now being designed.

The HEL's 204 professional, technical and administrative employees are looking forward to moving the laboratory's headquarters into a new, multimillion dollar 3-story facility later this year.

The laboratory's support facilities include a specially equipped area used to test soldier clothing and equipment and infantry weapons components; an up-to-date, computerized, outdoor, 150-meter, small-arms firing range; a special facility used to experiment with ammunition handling under day and night conditions; a farmhouse with five adjoining acres of land, and a building situated on two acres of land, both of which are used in MOBA studies.

The annual budget for the laboratory which comes from a variety of sources, has totalled approximately $12 million annually over the last few years.

Natick R&D Labs (NLABS)...

'We Make Things Better'

By NLABS Commander COL James S. Hayes

The ultimate weapon in the military's arsenal of weapons is the individual serviceman. He is the one who must fight to defend, or take and occupy the high ground. The mission of the U.S. Army Natick R&D Laboratories (NLABS) is to develop clothing and equipment systems to protect the serviceman, in all hostile and climatic conditions; food and food systems to feed him under these challenging conditions; and shelter and airdrop for him in this battlefield environment.

To accomplish this mission, NLABS has 1,300 military and civilian employees who share the important task of finding and fielding better ways to increase the individual combat soldier's performance and protection. This entails incorporating the latest state-of-the-art techniques to provide improved uniforms, combat clothing, field equipment and shelters, combat feeding systems, food preparation and serving equipment and systems, and the rapid delivery of needed personnel and supplies by air.

In the 1940's and before 1954, Natick's mission and resources were scattered at various sites throughout the country, fulfilling World War II and Korean War requirements. Those war experiences demonstrated that a centralized modern program of research and development, aimed at protecting and sustaining the soldier, was needed. On 19 April 1952, 177 years to the day after the opening of the Revolutionary War in nearby Concord, ground was broken at Natick.

Two years later, in October 1954, the doors were opened and facilities formerly at Lawrence, MA; Jeffersonville, IN; Philadelphia, PA; Cameron Station, VA; and Washington, DC, moved in while the Food and Container Institute, Chicago, IL, made the transition in 1963. From that day forward, Natick Laboratories and its staff became the centralized Army and military activity concerned with serving the needs of the individual soldier.

The Natick family consists of four major laboratories: Aero-Mechanical Engineering; Individual Protection, Science and Advanced Technology; and Food Engineering, as well as the Operations Research Systems Analysis Office. Two tenant activities, the Naval Clothing and Textile Research Facility and the Army Research Institute of Environmental Medicine work closely with NLABS.

LOCATED on 78 acres of land on the shores of Lake Cochituate and the town of Natick, 20 miles west of Boston, more than 1,300 military and civilian employees of the U.S. Army Natick R&D Laboratories share the task of finding better or new ways of sustaining and protecting the soldier in all environments.

The Aero-Mechanical Engineering Lab's aeronautical and mechanical engineers and parachute equipment specialists develop the means for delivering personnel and supplies from aircraft in flight, while other engineers within the lab design and develop the organizational support equipment and shelters.

Some past achievements include the highly efficient MC-1 steerable personnel canopy parachute and an anti-inversion net. Since adopting the net, the number of parachute inversion malfunctions has dropped to zero. The CTU-2A, a torpedo-shaped pod container dropped from beneath wings of high speed aircraft, delivers up to 500 pounds of supplies to pinpoint locations.

Delivery techniques being developed for the future include a static-line deployed 2-stage parachute system for safely dropping personnel from aircraft flying at 250-knots per hour and 500-feet altitude. A new controlled exit system permits delivery of a full aircraft load of equipment with minimum dispersion of the load and minimizes the time the aircraft and crew are exposed to hostile fire.

Another 2-stage system delivers 2,000 pounds from altitudes up to 10,000 feet while also in the development cycle is an ultra-high-level container drop system for delivering 2,200 pounds from 25,000 feet. In this system, altitude sensors activate parachutes at 2,000 feet.

The two laboratories at Natick that have the most intimate impact on the soldier are the Individual Protection Laboratory and Food Engineering Laboratory. This is because they provide the most basic necessities of life—protective clothing and food.

In the post war years, the Individual Protection Lab has significantly improved the well being of the soldier. Major improvements have been made in body armor protection, including the nylon vest used during the Korean War, the ceramic helicopter crew armor used in Vietnam, and the vastly improved personnel body armor system, consisting of a new helmet and protective vest introduced in 1978.

Made of high-strength synthetic Kevlar fiber, the 1-piece helmet provides 25 percent more ballistic protection than the M-1 steel pot while the vest, made of the same material, increases torso protection by 50 percent.

Natick has developed, for the Law Enforcement Assistance Administration, lightweight inconspicuous body armor which incorporates the Kevlar material into sport coats, raincoats and jackets.

New uniforms made of Nomex, a flame-resistant material, have been de-

veloped for both Army aviators and combat vehicle crewmen to protect against flame hazards. A new generation of chemical protective garments is emerging from an accelerated R&D program in this area.

Textile experts have developed a new woodland camouflage pattern for the equally new temperature zone battledress uniform and the same technique has been adopted, in a desert pattern, for operations in that environment.

Comfort, durability and protection are the keys to survival in the Arctic and, towards that end, Natick, incorporating the principles of insulation, layering and ventilation, has designed uniforms and footwear to protect personnel in temperatures down to −50°F.

Individual Protection Lab scientists are also developing material that will offer laser protection for the eyes as well as for the soldier's entire body.

To sustain troops in Arctic assault conditions, the Food Engineering Laboratory has refined the earlier freeze-dried dehydration techniques pioneered by its predecessor at Chicago and developed a compressed field ration which provides 1,500 calories per meal. Test results indicate high acceptance, both as to taste performance, as well as ease of preparation.

Compressed freeze drying permits storage of larger amounts of food in considerably less space—ideal for long range submarines or spacecraft. Thanks to such products developed for Army ground troops, astronauts Mr. Neil Armstrong and Mr. Ed Aldrin were able to eat the first meal ever on the moon in July 1969.

The dehydrated Long Range Patrol Food packet was a success in Vietnam and unusually high acceptance is now being gained by the Meal, Ready-to-Eat Ration which is replacing the Meal, Combat, Individual or "C" ration so well known to thousands of servicemen and veterans.

With the added development of flexible retort pouches for thermo-processed foods and the new flat, rectangular Tray Pack (T) Ration served from Mobile Field Service Units, combat troops can expect a wider variety of hot, nutritious meals.

Responsible for evaluating and developing improved feeding systems, the Operations Research Systems Analysis Office (ORSA) designed the Army's new "heat on the move and serve" combat feeding system concept which is now under accelerated development and test. The ORSA Office also originated the New Harvest Eagle Forward Field Feeding System for the Air Force which was successfully tested in Korea and will be procured in FY 83.

A redesign by the ORSA, of the food service system aboard the Navy carrier USS Saratoga, to reduce serving lines and provide high preference foods, has been so successful it has been implemented aboard all carriers and major ships of the fleet.

The Science and Advanced Technology Lab's research in physical, biological, behavioral and engineering sciences also provides the data base for use by the other commodity laboratories in seeking solutions to problems encountered in the development and procurement of materials and systems upgrading support to the soldier. Some examples include microbiologists investigating and developing biological and/or physical processes to assure the safety and stability of rations and feeding systems, as well as means to protect material from microbial deterioration or contamination.

In promoting the advancement of the military ration technology and the reliability of all DOD food service systems, biochemists and nutritionists are currently engaged in the major challenge of devising ways to protect food, and improve its preparation and serving in extreme and toxic chemical/biological warfare environments.

A number of unique facilities are available at Natick to assist the team of scientists and technologists in pursuing their projects.

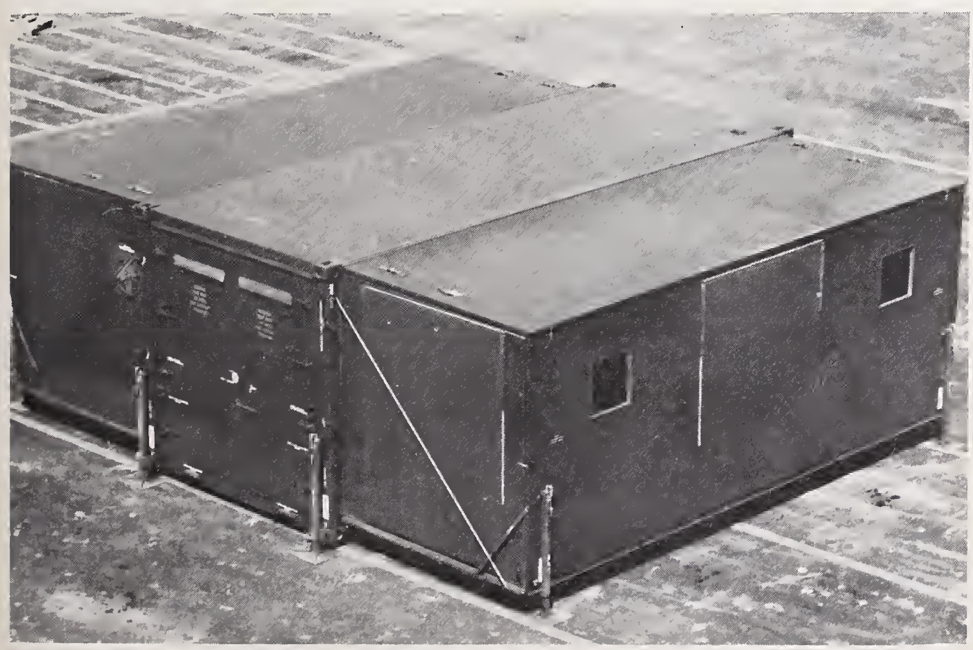
Within the climatic chambers, worldwide environments can be simulated, ranging from −70°F temperature with winds up to 40 miles per hour in the arctic chamber to a humid and torrid 165°F environment in the tropics. A separate raincourt facility produces up to four inches of rain an hour while in yet another location, the flame resistance of clothing and equipment is tested at an open fire pit.

A modern pilot plant containing the latest in baking, cooking, dehydrating, retort packaging and testing equipment is an integral part of the food research program.

A sophisticated array of equipment, including a carbon dioxide laser, Raman spectrometer, a nuclear magnetic resonance spectrometer, are of invaluable aid to the scientists while a third generation UNIVAC 1106 computer helps solve knotty technical and management problems.

At the beginning of the 1982 calendar year, the Natick Laboratories work force totalled 1,218 (96 military and 1,122 civilians). Eighty of this staff had earned doctorates while 142 had master's and 225 had bachelor's degrees.

A total FY 83 budget of approximately $65 million dollars, with the major portions allotted to R&D ($42 million) and O&MA ($20 million), is being diligently applied by a concerned staff, dedicated to making things better for the American soldier and assuring he has the best food, best equipment and best protection, no matter what the environment.



RIGID WALL SHELTERS, developed by the Aero-Mechanical Engineering Laboratory, eliminates several sizes and shapes of shelters now in the system. This 8' x 8' x 20' basic shelter can be expanded either on one or two sides.

The Intelligence Community/Laboratory Interface

U.S. Army Foreign Science and Technology Center

By FSTC Deputy Director Mr. Donald B. Dinger

The Army laboratories' source for scientific and technical intelligence relating to foreign nations' ground forces, excluding missiles and medical equipment, is the U.S. Army Foreign Science and Technology Center (FSTC), located in Charlottesville, VA. Included in its mission is the discovery of scientific and technological threats to the security of U.S. Army ground forces.

Included here are the identification of foreign technology and equipment improvements that could benefit the U.S. R&D community, and pinpointing deficiencies in foreign developments. The major goal of the FSTC mission then, is to prevent technological surprise by unknown or unprojected materiel advances from hostile or potentially hostile forces.

FSTC's workforce consists of approximately 570 military and civilian employees, of which approximately 420 are scientists, engineers, and intelligence research specialists. The annual FSTC budget is slightly in excess of $20 million.

The heart of the FSTC technical organization is the Intelligence Production Directorate and the Technical Services Directorate. The Intelligence Production Directorate consists of a Current Intelligence Office, four systems-oriented production divisions, and a Sciences Division which is the only science-oriented organization in the DOD intelligence community.

The Technical Services Directorate conducts highly technical imagery enhancement and electronic signal analysis laboratory-type efforts as well as providing printing, computer graphics, micrographics, and word processing support to the center.

Another key FSTC organizational element is the Army Foreign Materiel Office which manages the foreign materiel exploitation program. The majority of FSTC personnel are located in Charlottesville, but operating elements are also located at Aberdeen Proving Ground, MD, Yokota Air Force Base, Japan, and Frankfurt, Germany.

Intelligence production requirements are initiated by the materiel development community and result in a Defense Intelligence Agency approved production schedule and FSTC operates as a member of the national intelligence community in carrying out this production schedule. To accomplish this mission, FSTC provides outputs through a variety of media.

Through these various output media, FSTC has significant impact on the materiel development community. Recent examples are the M1 tank in which FSTC contributed to the selection of the 120mm gun and the M2 and M3 fighting vehicles, Advanced Attack Helicopter, and small unit support vehicles.

Other recent accomplishments included providing reports on advance foreign technologies in support of TACOM vehicle mobility research, ARRADCOM tank and artillery gun design, AVRADCOM advance helicopter materials technology, and signature data on foreign ground forces systems.

Because of the criticality of FSTC's outputs to the research, development, engineering, and acquisition (RDE&A) process, a number of initiatives are underway to enhance the working relationship and input of FSTC in the RDE&A process. These initiatives can be grouped into three categories:

- Initiatives to enhance FSTC working relationships with the RDE&A community. These laboratory initiatives range from direct interaction of the commander and staff of FSTC with DARCOM major subordinate commanders and directors to memorandums of understanding to coordinate on common items of interest.
- Initiatives to increase FSTC leverage on behalf of the RDE&A community. In this area, FSTC is improving its interactive data bases and computer networking. They are also increasing decompartmentation and sanitization of information to increase the availability of intelligence.
- Initiatives to increase impact of the Foreign Materiel Exploitation Program. Here efforts range from making foreign equipment documents available to the community to establishing a memorandum of understanding with other friendly governments for exchange of Soviet/Warsaw Pact military equipment and exploitation results.

U.S. Army Missile Intelligence Agency

By MIA Deputy Director Dr. Rankin A. Clinton Jr.

The job of producing scientific and technical intelligence on foreign missile systems belongs to the U.S. Army Missile Intelligence Agency (MIA), Huntsville, AL, with an authorized strength of 369 personnel.

MIA provides the Army, Navy, and Air Force R&D community with scientific and engineering definitions of current and projected selected foreign weapon systems. MIA and FSTC also support strategic and tactical operational commands, training and doctrine commands and operational test and evaluation agencies.

The agency's work is done under a current budget of some $20 million, and is housed in a recently acquired new 60,000 square foot facility, a facility that has been modified as an ultrasecure sensitive compartmented information center, the largest such one under Army control.

MIA performs in-depth analyses to provide support requested by a wide spectrum of DOD users, and distribution of multi-source information is accomplished in a variety of ways to include quick-reaction message documentation.

In recent years, MIA has also conducted extensive exploitation of foreign hardware, and the end product of this foreign materiel acquisition has been of inestimable value to the weapons acquisition/development cycle.

The agency continues to be deeply involved in the Army Development and Acquisition of Threat Simulation Program, managing the design, development, procurement, modification and replacement of this equipment. The simulators provide a realistic threat environment to support training, testing and development of new equipment and tactics.

Additionally, MIA has made many recommendations to the countermeasures community on countermeasures which should be added to U.S. systems to survive in the face of the hostile threat.

Testing Rotors in Model Scale

By Georgene H. Laub

A substantial portion of research of the Aeromechanics Laboratory, NASA-Ames Research Center (AVRADCOM), Moffett Field, CA, involves the testing of helicopter rotors in model scale. These experiments support continuing efforts to improve understanding of aerodynamics, structural dynamics, and acoustics of modern rotors.

Central to these investigations has been a versatile Rotary Wing Test Stand that makes many of these programs possible.

The system consists of several interchangeable units with control, monitoring, and on-line data acquisition capabilities making it readily adaptable to a variety of experiments and experimental facilities. It was conceived as a major tool for obtaining experimental aerodynamic, structural dynamic, and acoustic data on model helicopter rotors to correlate with full-scale wind tunnel and flight test data.

To facilitate investigations of the complex high-speed rotor flow field under controlled environmental conditions, pursuant to the development and refinement of aerodynamic, structural dynamic, and acoustic prediction theories, was the purpose behind the concept.

The study and design of the Rotary Wing Test Stand system was begun in 1973, and by 1978 it was put into service for the first rotor noise radiation test performed in the anechoic (acoustic testing) hover chamber facility of the Aeromechanics Laboratory.

In its several design configurations, the test stand is adaptable for testing not only in the anechoic hover chamber but also in the 2 x 3-meter wind tunnel that is operated by the Aeromechanics Laboratory.

The system can drive two or more rotor blades at speeds up to 3,000 rpm in either a clockwise or a counterclockwise direction. Further, it can operate with a 120-horsepower transmission driven by either two electric or two high-pressure-air motors or with a 500-horsepower transmission driven by three air motors.

Requirements of the test program dictate which transmission is used—generally the more quiet electric motors and the 120-horsepower transmission being selected for acoustic tests and the higher 500-horsepower transmission being chosen to power large rotors in the testing regime of high-drag, transonic tip speeds.

The upper shaft unit used with the 120-horsepower transmission is a multi-component force balance designed to measure thrust loads to 600 pounds and horizontal loads to 150 pounds. The swashplate control system used with the balance unit allows cyclic attitudes from −10 to +13 degrees and a collective attitude range of 16 degrees.

In the relatively short time the system has been operational, it has been proven a very valuable asset to the Aeromechanics Laboratory. It has been the test bed for 2 and 4 bladed rotors, rotors of 1.2 to 2.1 meters diameter, rotors with various airfoils, blade tips, and planforms, and rotors instrumented for pressure measurements.

Additionally, it has been used in test programs exploring such facets as rotor hover wakes, structure of shed tip vortices, laser visualization of three-dimensional flow fields at transonic tip speeds, and impulsive and blade-vortex interaction noise.

Although it was designed specifically for service in the anechoic hover chamber and the 2 x 3-meter wind tunnel, the test stand has been found reasonably mobile and readily adaptable for use in various other facilities and environments. For example, it withstood the hazards of being transported from country to country for service in cooperative research ventures.

During the past year, it was transported to France and used for a U.S./French cooperative research program in rotary-wing acoustics. The test was run as a totally cooperative effort that could not have been accomplished without the full support of both governments.

The reliability of the Rotary Wing Test Stand system was impressive. Many hours of testing were conducted during the 5-month long program with no significant operational problems, and several major technical achievements were accomplished.

The ability to use scaled-model rotors for the study and measurement of rotor blade-vortex interaction noise was demonstrated by comparing preliminary on-line French data with the equivalent full-scale acoustic data taken in flight. These new data should aid in pinpointing the causes and the potential design changes which will minimize the noise due to blade-vortex interaction.

Upon completion of the tests in France, the system was shipped to the Netherlands for the U.S. and Dutch/German cooperative research test program in their new acoustically treated wind tunnel facility, the DNW. Once again, the U.S. was given tunnel time and support for setting up the test stand in this very large, nearly anechoic facility. Test objectives were similar to those in the French test, except that higher flight speeds were possible and were included in the test program.

Additionally, this tunnel has inflow turbulence levels which are an order of magnitude smaller than the French facility. Since the DNW tunnel nozzle section is very large (6 x 8 meters), the majority of the measuring microphones were immersed in the slip stream making comparison with flight data quite easy. These efforts have provided the Army with valuable basic data enhancing the data base for the improved performance and reduced noise of helicopter rotors. This test covered a 2-month period, and once again, the Rotary Wing Test Stand demonstrated remarkable reliability.

Plans for the future utilization of the test stand system include the possibility of tests in the 4 x 7 meter VSTOL wind tunnel at the NASA-Langley Research Center, Hampton, VA, and an open field environment at the NASA-Ames Research Center.

The new system has permitted testing the same model rotors in a variety of facilities and environments. Utilization of the test stand frame, drive, control, and data measuring system in such different testing environments minimized concerns about comparability of data taken from the various test facilities.

During the less than four years since it was first put into operation, the test stand has adequately demonstrated the merit of its concept and the validity of its design.

GEORGENE LAUB is a research, operations, and facilities engineer at the Aeromechanics Laboratory, NASA—Ames Research Center, Moffett Field, CA. She holds a BS degree in aeronautical engineering from Purdue University and an MS degree in aeronautics and astronautics from Stanford University.

The Aeromechanics Laboratory is one of four laboratories of the HQ U.S. Army Research & Technology Laboratories (AVRADCOM). Both units are located at NASA-Ames Research Center, Moffett Field, CA.

Army Corps of Engineers Laboratories

Introduction by Dr. James Choromokos Jr.
Assistant Chief of Engineers for R&D and R&D Director, OCE

The U.S. Army Corps of Engineers conducts both military RDT&E (primarily 6.1 & 6.2) and civil works R&D and directs five laboratories: the Cold Regions Research and Engineering Laboratory, Hanover, NH; the Coastal Engineering Research Center, Fort Belvoir, VA; the Construction Engineering Research Laboratory, Champaign, IL; the Engineer Topographic Laboratories, Fort Belvoir; and the Army Engineer Waterways Experiment Station, Vicksburg, MS.

In addition to our direct funded RDT&E, the Corps of Engineers also is the Department of the Army director monitor for environmental services. This includes the tech base R&D program at two DARCOM laboratories, Atmospheric Sciences Laboratory and Toxic Hazardous Materials Agency, and one Surgeon General laboratory, U.S. Army Medical Bioengineering R&D Laboratory.

All Corps laboratories conduct both civil works and military RDT&E except the Coastal Engineering Research laboratory which conducts only civil works R&D. The Directorate of R&D for the Corps is responsible for the R&D program of over $165M that includes both civil works and military RDT&E as well as reimbursable work.

Reimbursable work includes advanced systems development for DARCOM, DMA, DNA and the other services, where customers come to our laboratories to have specific R&D performed. Because of the variety of R&D (RDT&E, civil works and reimbursable), we obtain a tremendous amount of synergism which benefits all programs. Personnel in the five Corps laboratories totals over 2,300.

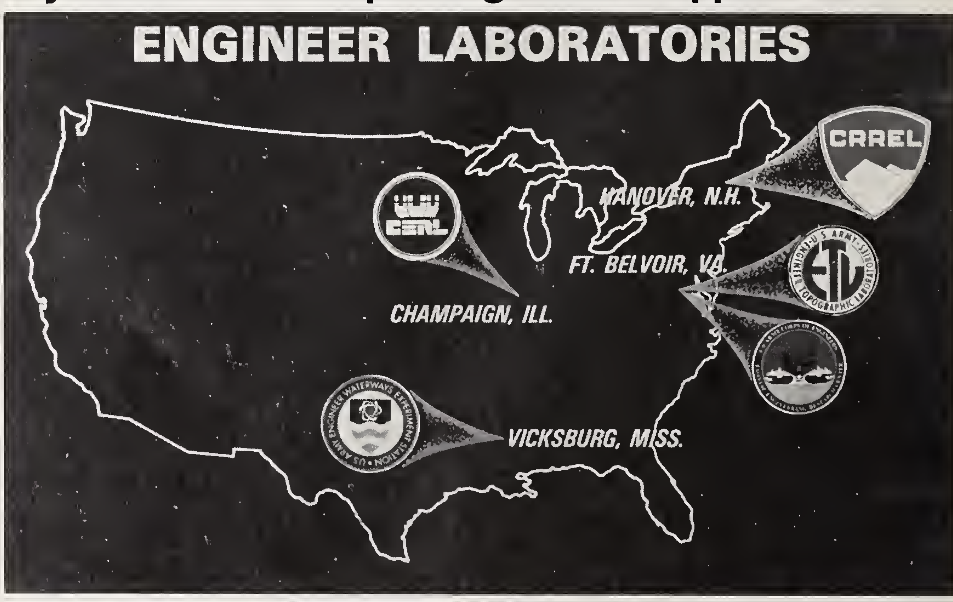
Our military program is focused in three areas. First, is the characterization of the battlefield environment and its impact on Army operations and materiel. Included are weapons and natural environmental effects from the desert conditions of Southwest Asia and the winters of Northern Europe. Second, is the Army combat role and the support provided by combat engineering in mobility, countermobility, survivability, topographic science, and general engineering. Third, is the acquisition, construction, maintenance and operations role of the Corps for base/facility development and installation support to the Army and other services, including environmental quality and quality of life improvements for Army facilities.

In support of the Corps' civil works mission, the research encompasses coastal engineering, flood control and navigation, construction materiel, environmental quality of waterways, remote sensing, and ice engineering.

In summary, the Corps program is forward looking and responsive to the needs of the Nation, the Army and the Corps of Engineers. The following articles discuss the activities of 4 of the 5 Corps of Engineers laboratories.

CERL Conducts Key Mission of Improving Base Support

By CERL Commander/Director
COL Louis J. Circeo Jr.



With most of the Army's physical plant over 25 years old, the principal mission of the U.S. Army Construction Engineering Research Laboratory (CERL) at Champaign, IL, is to attack this most significant need—base support.

The Army's bases were built for yesterday's Army and yesterday's soldier. Weapons systems for today's Army call for modern facilities and sophisticated equipment. Today's volunteer soldier requires higher quality living quarters and services for him and his family. However, the ever-increasing cost of utilities for operating the Army's aged physical plant is making otherwise-suitable facilities "unaffordable"—and the high cost of new construction and recurring repair and maintenance compounds this problem.

The approach taken to solve these problems is to provide technology and systems to make military facilities technically and economically affordable.

The laboratory's technology areas correspond to the stages of real property management in the Army, ranging from master planning through acquisition and construction to operations and mainte-

nance. The technology includes lead laboratory responsibilities in energy conservation of fixed facilities and environmental quality management of all Army activities at an installation.

CERL's accomplishments can be described best in terms of emphases which have prevailed during the last 10 years. The first is to improve productivity of the limited Army resources available to plan, design, and build new facilities. CERL is developing a computer-aided design system to assist the Army engineer—the computer-aided engineering and architectural design system.

This system will consist of three phases. A pre-design phase will assist installation planners in automated master planning and initial project development. The concept design phase is an integrated set of automated design tools which will provide design layouts validated against design criteria, energy budgets and the cost estimates for the 35 percent design level.

The final design phase will be an integrated set of automated design tools for the 100 percent design of the major systems in a facility (structural, mechanical, etc.), and the final procurement documents (specifications, cost-estimate, detailed drawings, etc.).

Separate modules of concept design were recently integrated into a single system. In a pilot test using standard drawings, the concept system was applied to the designs for over 100 projects in the FY 84 military construction Army program. Results thus far are highly successful, with indications of significant savings in both cost and time.

Two recent accomplishments that will become a part of this computer-aided design system, are the building loads analysis and system thermodynamics system and the computer-aided specification preparation system. The first of these is a comprehensive set of programs for predicting energy consumption and energy systems performance and cost in buildings. It also estimates annual energy performance of the facility, which is essential for the design of solar and total energy systems and for determining compliance with design energy budgets.

The second system is an automated specification preparation system unique to military construction. Both systems are in active use by Army engineers with annual savings in the multi-million dollar range anticipated.

The second CERL activity addresses the need to coordinate military facility modernization with reduced maintenance and repair costs. This research takes advantage of the latest technology in industry. A typical example is roofing. Roofs on Army facilities currently require maintenance and repair in excess of $50 million annually, and have a history of leaking within a few years of placement.

CERL is investigating potential Army use of single membrane roofing in answer to this problem. If successful, this technology could reduce roof maintenance costs by 40 percent. Other technologies in this activity are in pollution abatement and energy conservation.

The third research activity is to reduce repair costs in non-destructive testing of materials on site. For example, improper welds lead to safety problems, and an improper weld costs five times the original weld cost to correct. The weld quality monitor is being developed to evaluate the quality of a weld as it is being made—in real time. It is on-line at the Abrams tank production plant in Lima, OH, and tests have been so successful that a change to a less expensive weld rod is planned.

A fourth need is to improve the productivity of limited resources available to the facility engineer to maintain and operate the physical plants. CERL research in this area is designed to enable the facility engineer to systematically select what facility to maintain/repair and to determine what quality of repair.

The pavement maintenance management system helps the facility engineer optimize the allocation of resources in roads and streets maintenance. An FY 81 test at Fort Eustis resulted in pavement maintenance management costs of $79 per lane mile with the pavement system, compared to $158 per lane mile cost for a manual system that was in effect. Utilizing this system, the Fort Eustis backlog of pavement maintenance and repair is being rapidly reduced. Other such systems in development are for roofing, corrosion, railroads and utilities.

In the fifth thrust area—the facility engineer's management of operations—CERL has developed technology and automated sytems to minimize costs. For example, the environmental technical information system has been developed to calculate the environmental impacts of military construction and military operations. This system is being extensively used throughout the Federal Government. Additionally, energy conservation technologies ranging from time clocks through energy monitoring and control systems are being tailored for Army use.

The newest of the five Corps of Engineers laboratories, CERL was established in 1968. It is located on a 30-acre site at the Interstate Research Park in Champaign, IL, where it can take advantage of the resources and facilities of the University of Illinois.

The CERL interdisciplinary research team consists of 124 scientists and engineers assisted by 29 technical support and 58 administrative support personnel. Nine of the staff members are military personnel.

In FY 81, CERL's total program was $18.5 million, of which $8 million was direct RDT&E funding and $7.5 million was reimbursable funding principally from the Office of the Chief of Engineers and Corps divisions and districts. Other federal agencies accounted for the remaining $3 million.

CRREL Programs Enhance Army's Cold Regions Mission

Winter—snow, ice, frozen ground. These environmental extremes occur in over half the Northern Hemisphere. The penalties of winter conditions must be overcome by the military on the battlefield as well as in the garrison. Even the civilian populace must learn to effectively adapt to winters in cold regions.

Serving the Army and the nation in understanding the particular characteristics of the cold regions, how it affects man, and how it is affected by man, is the Army Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL), Hanover, NH.

CRREL's roots go back to World War II and the construction of the Alcan Highway and construction of defense facilities in Alaska. It was involved in, and continues to work on the construction and maintenance of the DEW line facilities in Greenland.

In 1977, CRREL engineers developed the concept for the successful move of one of the DEW line radar stations to a new foundation on the icecap. The move of the 3,300-ton structure resulted in a savings of $1.5 million when compared with building a new one. The move of a second structure is planned for this summer.

Additionally, CRREL staff members are active in the nation's space exploration program, participating in the development of the hardware used on the Mars Mariner lander which analyzed the soil and made determinations for the presence of moisture. Currently, CRREL is studying the potential for the build-up

of ice on the fuel tank of the space shuttle. Ice breaking off during launch could damage the heat shield tiles.

Winter imposes a unique set of conditions on the battlefield, so CRREL research looks at defining the environmental conditions of the winter battlefield which must be considered by the hardware developers and the tactical planners.

Snow, frozen ground, thawing ground, and ice on rivers and lakes all affect mobility. Snow and frozen ground limit the performance of mines. Frozen ground restricts standard excavation techniques, whether for building of revetments or repair of bomb damaged runways.

A major research effort at CRREL is to study the effect of winter conditions—snow, ice, fog, rain, cold—on the sophisticated electro-optical and millimeter-wave systems currently in use or under development for target acquisition and guidance.

The lab is coordinating a series of "SNOW" field experiments to quantify the influence of the winter environment on such systems. After two winters of study, the environmental characterization program has developed a data base for electro-optical and millimeter-wave propagation through snow that can be utilized with confidence in developing statistical analysis.

For permanent Army bases, CRREL research is seeking ways to build more energy efficient structures in the cold regions, and in this quest has developed new design standards for snow loads on roofs. Various types of commercial roofing insulations are being examined to determine the amount of moisture which may penetrate the insulation and its effect on insulation values.

CRREL pavement engineers have recently published a "Pothole Primer" which addresses the understanding and management of pothole problems in asphalt pavements. It is intended for non-engineers in understanding the major causes and general solutions to the universal pothole problem.

SNOW characterization instrumentation being used by CRREL in SNOW field experiments include (from left) holocamera, electro-optical particle-size probes, and snow-content meters.

CRREL served as the Corps' lead laboratory on a project to develop the design criteria for the treatment of sewage wastewater by application to land areas. This program, funded under the Corps' urban studies project, resulted in the publishing of the *Process Design Manual for Land Treatment of Municipal Wastewater*, in coordination with the Environmental Protection Agency, the Department of Agriculture, and the Department of Interior. The land treatment process offers an attractive, cost effective alternative.

CRREL has a staff of 300, including more than 100 research scientists and engineers. Expertise of the professional staff has resulted in the lab's participation in many national and international programs.

CRREL personnel served in an advisory capacity to the government in the design and construction of the Trans-Alaska Oil Pipeline, and currently, it is assisting government agencies on the proposed Alaska natural gas transmission system.

At present, scientists from Japan and the Peoples Republic of China are conducting research at the Hanover, NH, facilities. This past winter, two CRREL scientists conducted studies in Antarctica's Weddell Sea while on board a Soviet icebreaker.

Specialized facilities at CRREL include a large Ice Engineering Laboratory, which provides refrigerated areas where scale model hydraulic ice studies may be conducted. This program is part of the Corps' civil works efforts in support of the nation's waterways. Problems addressed include understanding and preventing or controlling ice jams, alleviating icing problems in navigation locks and dams, and prevention of icing of hydropower water intakes.

The final dividend of the extensive and varied research program of CRREL is information which enables the Army to achieve its mission in the cold regions of the world.

The preceding article was prepared by key personnel at the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory.

ETL Supports Terrain Requirements Through Intense R&D Programs

Modern developments are changing the nature of combat. The scope, accuracy and methods of supporting topographic requirements are also changing.

Coming to grips with these modern changes, the research and development community, along with developers and users, is taking a hard look at how to manage and use vastly increased amounts of battlefield information for effective coordination and control of modern fighting units and weapon systems.

Performing the full range of R&D services, from basic research through engineering development in the topographic sciences, the U.S. Army Engineer Topographic Laboratories (ETL) reports directly to the Chief of Engineers. ETL personnel are actively involved in supporting Army modernization and, where applicable, in transferring defense technology to the civil works element of the Corps.

Two major clients are served—the Defense Mapping Agency and the Army Materiel Development and Readiness Command (DARCOM). Along with these major elements, ETL also serves the Army Space Program Office and other Department of Defense and governmental agencies. ETL's Terrain Analysis Center, the only production-oriented element of the laboratories, responds to, among others, the Assistant Chief of Staff for Intelligence by preparing special terrain studies.

Systems developed for the Defense Mapping Agency enable rapid map com-

pilation and drafting at lower costs and with greater accuracy at base printing plants.

In conjunction with DARCOM, ETL personnel are responsible for delivering high-precision positioning systems for the field artillery, target positioning equipment for tactical missile units, and improved systems for reproducing maps portraying specific military geographic information needed by the Army in the field.

Currently, the terminal guidance system for the Pershing II missile is one of the top priorities for the cadre of scientists and engineers who work in the laboratories at Fort Belvoir, VA. Accuracies required for siting the Missile X are also being addressed. Workers are busily targeting their energy on improving astrogeodetic and inertial survey technology.

Back on the ground, in a fast-paced, no-nonsense situation, a printer that gives commanders quick-response, combat-oriented terrain maps is essential. Spearheaded by ETL researchers, and now in advanced development, the Quick Response Multicolor Printer is especially designed for low-volume, ''need it now'' conditions. With an eye on the future, these researchers are looking into the possibility of a digital interface for the printer. If this should occur, maps could be printed from digital data bases, as well as from paper.

Today, the soldier and the standard topographic map play key roles in determining enemy weapon locations. Tomorrow that may not be the case. A dubbing facility, now being developed at ETL, will serve as a critical field link between DMA digital data and the ultimate user in the field. It is being developed to support the Firefinder weapon location system. This data conversion facility, expected to be out of the laboratory environment this summer, could also support other weapon systems.

Digital terrain elevation data that are already being produced at the Defense Mapping Agency will be able to be verified, reformatted and transferred onto a militarized tape cartridge that is compatible with Firefinder computers. This facility will be the first of its kind delivered to a tactical unit and it should greatly improve accuracy and responsiveness.

Research now in progress at the laboratories is indicative of the change taking place in topographic support. There is a definite shift in emphasis from the classic function of providing static, two-dimensional, conventional maps to a modern function of providing quick-response, three-dimensional, dynamic products using digital topographic data.

A Digital Terrain Analysis Station is being used by software developers in order to work on digital topographic data bases. The focus is on generating computer graphics similar to cross-country movement overlays and other tactical graphics that are now laboriously prepared by hand. Recently, ETL was given the responsibility for developing a digital system that can deliver the terrain portion of information requirements for the all-source analysis system.

Another facility, dubbed Computer-Assisted Photo Interpretation Research, was set up to take on the challenge of producing cost-effective, high-quality, geographic data files. Scientists who are working at this facility are investigating direct-data entry into existing digital files. Capturing, validating, updating and, thus, managing geographic data, is easier, faster and more precise.

Driven by new topographic doctrine and organization, technical experts designed a topographic support system that is due to replace antique equipment now in topographic units. Headed for Europe in FY 84, the system is modular, mobile and evolutionary: modular to adjust to battlefield conditions; mobile to maintain contact with tactical forces at the lowest possible echelon; and evolutionary to keep pace with advancing technology.

The effort to apply military R&D to the civil works program adds a further plus to the productive output of the R&D effort and serves to increase positive returns on the funds expended for defense of the nation.

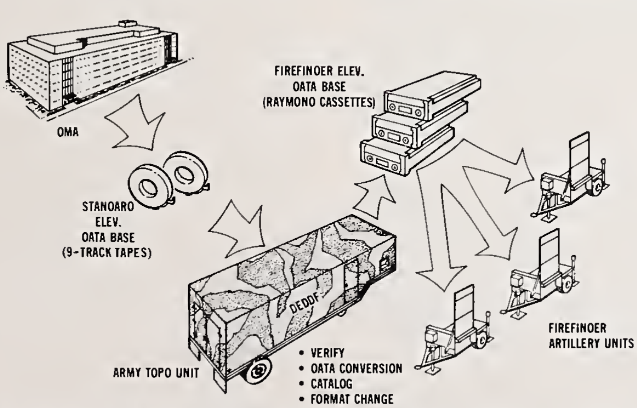
Always aiming at quick, cost-cutting and accurate methods for military applications, ETL personnel realize that much of their R&D has spin-offs in the civilian community. The Position and Azimuth Determining System and the lightweight gyrocompass, both developed for the field artillery, have been successfully marketed in commercial versions for civilian use.

ETL is the Corps of Engineers' principal laboratory for remote sensing. This civil works-funded program includes activities at other laboratories and is oriented toward using remote sensing information in water resources, inland waterways and flood control projects.

Many Corps dams are being monitored by surveyors schooled in the use of an ETL technique that makes it possible to spot minute movements in huge structures. This technique is being used in support of the Corps of Engineers' dam safety program. Engineers will soon be able to pinpoint stress areas, and to determine what is causing the stress, by a tilt monitoring method that is now being introduced.

Named 1976 Most Improved Army Laboratory, ETL won further distinction as the 1977 Army Laboratory of the Year. Once again, ETL was named Most Improved Laboratory for 1981.

ETL's work force of over 300 civilian and military personnel has come a long way from the 1920 temporary engineer detachment that was formed under MAJ James Bagley, U.S. Army Corps of Engineers. Bagley set the stage for radical change when he began testing the use of aerial photographs for mapmaking purposes. Today, ETL's researchers are harnessing the technical explosions in digital array techniques, coherent light, data storage, and other disciplines to answer the same question: What is the terrain like?



ETL's Digital Elevation Data Dubbing Facility will convert Defense Mapping Agency digital data to a form usable by Firefinder weapon locating radar.

The preceding article was prepared by key personnel at the U.S. Army Engineer Topographic Laboratories.

Waterways Experiment Station (WES)...

Principal Missions Support Military, Civilian Requirements

Who in the Army analyzes and devises solutions for such things as bomb damage repair of pavement, protective structures, nuclear and conventional explosive effects, tunnel detection, and seismic sensors? These and many other tasks fall under the mission of the U.S. Army's Corps of Engineers Waterways Experiment Station (WES), Vicksburg, MS.

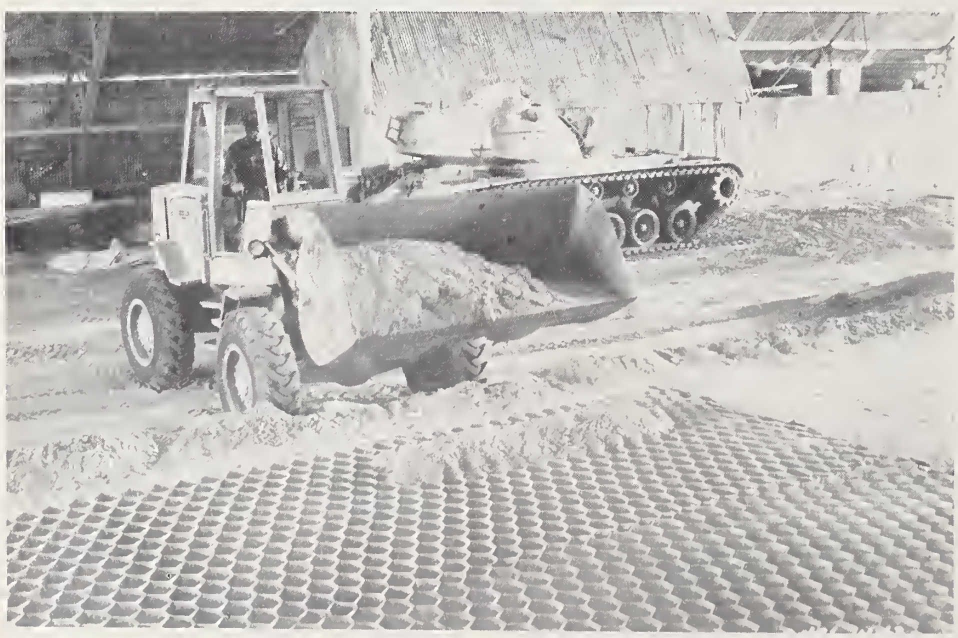
WES is one of the principal Army research, testing, and development facilities under the U.S. Army Corps of Engineers. Its mission is to conceive, plan, and execute engineering investigations, and research and development studies to support both the civil and military missions of the Chief of Engineers.

This work is done in four laboratories. Fields of research include hydraulics, soil and rock mechanics, earthquake engineering, concrete technology, expedient construction, nuclear and conventional weapons effects, nuclear and chemical explosive excavation, vehicle mobility, engineering geology, pavements, protective structures, environmental relationships, aquatic plants, water quality, and dredged material.

In addition to purely military needs, national problems addressed at WES include maintaining and improving the nation's waterways for navigation, controlling floods, designing of harbors, avoiding problems caused by the liquefaction of soils, preventing loss due to earthquakes, insuring safety of dams, proper disposing of dredged material, controlling aquatic plants, proper disposing of solid and hazardous wastes, treating wastewater, restoring wetlands, insuring water quality, providing recreation, detecting tunnels and cavities in the subsurface, insuring adequate structural strength, determining methods of trafficability over beach sands, constructing airfields, and using explosion effects for civil as well as military purposes.

The Hydraulics Laboratory was the original "Waterways Experiment Station," and its principal tools are physical and numerical hydraulic models. A group of engineering specialists, continually honing its intellect on research, has always been ready and able to address new problems in hydraulics and hydrodynamics.

For more than a half century the laboratory has developed both physical and numerical hydraulic modeling to an art that produces results of tremendous value. The results are used in the design of dams, planning and construction of flood-control levees, river and harbor construction projects, soil-erosion control, streambank erosion, thermal pollution, and water quality, and in many military applications.



Front-end loader fills sand-grid confining system for improved beach trafficability in Geotechnical Lab, Waterways Experiment Station, Vicksburg, MS.

Another key area is that of the Geotechnical Laboratory where some 200 military and civil research projects are underway. Some of the more significant military study areas are vehicle mobility research, repair of bomb damaged runways, tunnel detection methods, repair of war-damaged port facilities, sand treatment for mobility enhancement, railroad rehabilitation for mobilization, non-destructive testing and recycling of airfield pavements, and pavement and foundation design.

The Geotechnical Laboratory recently occupied a new building named in honor of Prof. Arthur Casagrande who was recognized as an outstanding specialist in soil mechanics and foundation engineering. With the modern laboratory facilities in the new building, Corps support for the Army is being significantly improved in such areas as advanced analysis of soil liquefaction processes and development of high volume material testing techniques, as related to permanent military facilities, better tunnel detection methods, improved military pavement design, and theater of operations horizontal construction.

The Structures Laboratory conducts investigations to determine the phenomenology and effects of explosions and studies the response of structures to such loadings. Effects of earthquakes on concrete dams and other structures are studied. The lab also investigates effects of natural and artificial environmental influences on structures and on structural materials.

Additionally, the lab carries out research on the behavior of soils under dynamic loading conditions, the effectiveness of various structural design concepts in withstanding specific design loads with appropriate margins of safety, and the feasibility and cost-saving aspects of performing excavation with explosives, or, through the use of explosives in conjunction with conventional excavation techniques. The total research effort of the laboratory involves theoretical, analytical, experimental, and modeling approaches. Its motto is: "To Build Better."

Hydrodynamic codes are used to calculate kinds and amounts of explosives

to be used to simulate the blast and shock effects of nuclear explosions. Effects of such detonations and the transmission of these effects through single- and multi-layered media are calculated. Small-scale laboratory and large-scale field experiments are conducted to verify or modify the codes.

The lab also accomplishes partitioning of explosive energy into various media, resulting from detonations that occur at various heights or depths of burst, and the transmission of the shock energy through the various media which provide data upon which to base the design of protective and strategic structures. Scale models of a wide assortment of structural types are also tested to determine response characteristics and vulnerability, and to assess the internal shock environments.

Finite element computer codes are developed and used to predict the response of structures to the dynamic loadings associated with nuclear or non-nuclear explosions, and to predict the response of structures such as concrete dams to the effects of earthquakes.

Research in the Environmental Laboratory answers questions on the effects of man's activities on the environment as well as the effects of the environment on military operations and materiel. It is the lead laboratory for the Corps in the field of military hydrology, fixed-installation camouflage, and mine/countermine programs.

Military hydrology provides techniques for locating probable water sources in arid environments and producing new methods for tactical streamflow forecasting to assist in planning military operations such as bridging streams with floating bridges.

Fixed-installation camouflage is leading to new techniques for hiding key elements of fixed facilities from visual, thermal, and radar target acquisition devices to increase their survivability.

The mine/countermine program will provide a technology base to define the range and nature of terrain anomalies created by mine placement, provide methods to locate and evaluate mined areas as a function of terrain and environmental changes, develop concepts and criteria for using explosives and simulated target signatures for neutralization, and provide analytical models, concepts, and criteria to improve mine/countermine operations for transfer to equipment developers.

Special study areas include the treatment and management of wastewater, urban runoff, or other wastes and pollutants produced by industrial or other activities. A geographically based information system capable of storing, retrieving, displaying and analyzing multiple environmental factors has been developed.

WES testing program includes use of both physical and numerical modeling techniques to address the problem of shoaling in the Sunny Point Terminal, Cape Fear River, NC. The Military Ocean Terminal, Sunny Point, operated by the Military Traffic Management Command, is in Brunswick County, NC.

The WES staff is proud of their recent accomplishments in the areas of vehicle mobility, pavement design, soil stabilization, concrete technology, bomb damage pavement repair, nuclear and conventional explosive effects, protective structures, and seismic sensors. In addition, major contributions have been made to the technology of flood control and navigation studies, earthquake damage prevention, beach erosion and sand bypassing, dredged material disposition, aquatic plant control, tunnel and cavity detection, and reservoir water quality.

Recent new areas of emphasis at WES include thermal camouflage studies, military hydrology, installation restoration, hurricane surge studies, water quality research, streambank erosion, mathematical modeling, solid and hazardous waste research, wetlands research, maintenance and repair of hydraulic structures, sediment transport, and the development of coastal wave information.

A unique feature that differentiates WES from other DOD R&D installations is the degree to which its program simultaneously, and in an integrated way, serves both the military and civil needs of the nation as these are embodied in the Corps of Engineers mission.

WES scientists and engineers have some of the most complete and sophisticated testing facilities in the world to carry out their R&D to solve important problems affecting our nation's safety and its vital natural resources.

WES has made major contributions to the Nation's growth and development. It supports the total Army and, through its research, meets the needs of the Army's military mission. The civilian staff of 1,316, augmented by 15 military personnel, includes 779 engineers, scientists, and technicians.

Research at WES is funded directly from the Office, Chief of Engineers and on a reimbursable basis; Congress makes no direct appropriation for its operation. Sponsoring organizations pay for all costs incurred in carrying out the work they request. There are presently 1,200 active projects underway with 120 sponsors. This represents a work program of around $70 million.

The preceding article was prepared by key personnel at the U.S. Army Corps of Engineers Waterways Experiment Station.

Army Medical R&D Command...

Individual Soldier Viewed as 'Most Important' Battlefield Asset

Introduction by MG Garrison Rapmund
Commander, U.S. Army Medical R&D Command

The motto which describes the tradition and worldwide mission of the U.S. Army Medical Research and Development Command (USAMRDC) is "Research for the Soldier," because the soldier is considered the most important and the most vulnerable component of all battlefield systems. The medical R&D program of the Army then, is geared to address problems which may cause the soldier to become inoperative or operate at reduced efficiency under a variety of physical, psychological and disease stresses in a wide array of environments.

To provide overall management and direction to the multi-disciplined and multi-faceted R&D efforts of the Office of The Surgeon General of the Army, is the purpose of the U.S. Army Medical R&D Command headquartered at Fort Detrick, Frederick, MD. Research and development is organized into five general areas: military disease hazards, combat casualty care, health hazards of military systems and combat operations, combat maxillofacial injury and medical defense against chemical agents.

The USAMRDC commander is responsible for the planning, coordinating, directing, executing, and reviewing the Army-wide medical RDTE program. The Surgeon General provides the essential command guidance and personnel resources, while funds and general program guidance are received from the Office of the Deputy Chief of Staff for Research, Development and Acquisition, DA.

The medical research program is conducted in the United States and, to a limited degree, in other countries. Medical R&D efforts are performed in military laboratories by more than 2,900 military and civilian investigators, technicians and support personnel. These activities are complemented by more than 375 research contracts with universities, nonprofit research organizations, and industry.

Approximately 55 percent of these contracts are with educational institutions. Some research is conducted in other government laboratories such as those of the Department of Agriculture and the National Bureau of Standards. The following are descriptions of research activities at each USAMRDC laboratory.

Walter Reed Army Institute of Research

Walter Reed Army Institute of Research (WRAIR) is the oldest and largest of the USAMRDC laboratories. Founded in 1893 as the first school of preventive medicine in the United States, WRAIR has always had, as an associated mission, the conduct of research in the field of military preventive medicine. Today, the mission includes studies in combat casualty care.

The FY 83 budget for the institute is in excess of $26 million. Courses include tropical medicine, military veterinary medicine short course, the animal specialist (91T) course, the military preventive medicine residency and the infectious disease fellowship.

Staffed by approximately 825 researchers and support personnel, the workforce is about equally divided between military and civilian. Advanced degrees are held by many of the people assigned to WRAIR, and embrace a wide variety of disciplines.

WRAIR pursues a research program which extends from basic research through product development. Goal-directed basic research is aimed at understanding the molecular biology of agents causing militarily important diseases such as hepatitis, shigellosis and malaria. These studies are complemented by basic studies of immunology and epidemiology.

Basic studies in neurophysiology and behavioral psychology are aimed at discovering determinants of behavior and response to stress and lead to better understanding of combat psychiatric problems.

Exploratory development, supporting all the USAMRDC labs, covers four of the five Command research areas; military disease hazards, combat casualty care, systems health hazards and medical defense against chemical agents. An example of ongoing work is the development of genetically engineered Shigella vaccines. New approaches such as genetic engineering and production of monoclonal antibodies are applied to development of disease prevention measures.

In product development, vaccines for dengue fever, a tetravalent meningococcal vaccine, a vaccine effective against drug resistant gonorrhea, antimalarial/leishmanial drugs and antidotes for organophosphate compounds are nearly ready for human testing.

Much of the work of WRAIR goes on in the main laboratory located at the Walter Reed Army Medical Center in Washington, DC. However, small elements of WRAIR have operated overseas since MAJ Walter Reed led the Yellow Fever Commission to Cuba in 1900. WRAIR researchers are presently in Thailand, Malaysia, Kenya, Brazil, West Germany, and Egypt.

WRAIR also has command responsibility for management of a broad program of extramural research. Contracts with leading university and industrial laboratories greatly expand the USAMRDC capability in neuropsychiatry, infectious disease and drug development research.

Together with the additional responsibilities in combat casualty care, WRAIR continues its traditional research and teaching program dedicated to preventive medicine and the preservation of combat effectiveness.

Army Medical Research Institute of Infectious Diseases

Conducting studies on the pathogenesis, prophylaxis, treatment and epidemiology of infectious diseases, is the mission of the U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID), Fort Detrick, MD.

Particular emphasis is placed on problems associated with medical defense against potential biological warfare agents, or naturally occurring diseases

of particular military importance and on the highly virulent pathogenic microorganisms which require special containment facilities.

In the past year, USAMRIID, a component of WRAIR, in cooperation with the U.S. Air Force, has developed the capability of sending a unique medical team to distant locations to bring back military patients using the most stringent isolation procedures. These procedures are necessary for patients who have, or are suspected of having any one of several highly hazardous and contagious diseases, such as Lassa, Marburg, or Ebola fevers or other hemorrhagic fevers.

The procedure consists of placing a patient in a plastic-enclosed stretcher, totally isolating the patient from the attending medical and Air Force personnel. These plastic units are equipped with air lock seals and special microbiological filters, and provide the highest level of biohazard containment.

The stretcher unit can be moved in Army medical evacuation helicopters, ground vehicles of light truck size, or in small buses. Once the patient has been moved to an Air Force hospital transport plane, they will be transferred without contaminating the attending medical personnel to a somewhat larger unit, the aircraft transit isolator.

Initial loading in the field must be done by medics who are protected by impermeable suits. These are decontaminated with disinfectant solution after the patient is "buttoned-up" in the isolator. The transit isolator provides the patient with more room and comfort and allows attending medical personnel greater accessibility for providing care. Once the patient has been transported by air and bus to USAMRIID, he is transferred into a unique containment suite where state-of-the-art medical treatment can be provided. In this suite environment, the patient is not surrounded by a plastic enclosure; instead, attending medical personnel must wear protective plastic suits with their own air supply. Each of the transfers from the field to carrier, to the containment suite can be done without breaking the isolation barrier and without exposure of personnel who move the patient.

In summary, USAMRIID, in conjunction with the Air Force, now has the capability to transport highly contagious patients via land and air from any continent without endangering the medical attending staff. At the institute, state-of-the-art medical care, including fully protected clinical laboratory support, can be provided to the patient. Major problems which have been solved are: conformity with existing USAF equipment, independent and rechargeable power sources for use in remote areas, and in-flight and non-interference with aircraft electronic systems.

Letterman Army Institute of Research

Letterman Army Institute of Research (LAIR), Presidio of San Francisco, CA, is a complex of modern buildings with a staff of about 275 investigators, technicians, and support personnel to carry out the research missions that include battlefield casualty management, military trauma and resuscitation, effects of military lasers, blood substitutes and preservation, and chronic mammalian toxicology.

LAIR's organizational structure includes four medical research divisions, a research support division, an information sciences group, and administrative and logistic support elements. The current in-house research budget amounts to nearly $7 million and is supplemented by more than $3 million in extramural contracts.

In the last 10 years, LAIR's researchers have distinguished themselves in the fields of military nutrition, battlefield blood substitutes and preservatives, and laser safety. Extending blood shelflife by 60 percent is one example.

In 1978, the Food and Drug Administration approved a 35-day shelflife blood preservation method based upon documentation provided by LAIR investigators who directed a 5-hospital cooperative clinical study. More recent findings increase storage time up to 49 days. Blood banking procedures resulting from this research are now worldwide.

Although no longer the DOD performing laboratory for nutrition, LAIR has been assigned the new mission of determining basic toxicology of militarily unique materials (explosives, propellants, repellents, and others). The ocular hazards program continues to provide information on laser safety and has extended its studies to more wave-lengths.

Efficacy and safety of blood substitutes, such as perfluorochemical and hemoglobin solutions, are being evaluated for situations where blood is not available. Work has been started on the new generation of high velocity missile induced wounds. In general, combat casualty care problem areas have been assigned to LAIR for resolution.

Army Institute of Surgical Research

The U.S. Army Institute of Surgical Research (USAISR), also known as the Army Burn Center, is located at Fort Sam Houston, San Antonio, TX. Its mission is investigation of problems of mechanical and thermal injury, and the complications arising from such trauma, care for patients with such injuries, conduct of studies at the basic and clinical levels, and training of physicians and ancillary medical personnel in the principles of management of thermally injured patients.

USAISR has served as the model for other burn centers throughout the world. Some of the many advances in burn care which have emanated from the institute are: the Brooke formula for fluid volume replacement; development of topical sulfamylon burn cream; establishment of the first Army renal dialysis unit; use of biologic dressings for temporary burn wound coverage; development of diagnostic means, including the use of the 133 Xenon lung scan, to detect inhalation burn injury; use of the ultrasonic flow meter to assess adequacy of peripheral circulation in patients with circumferentially burned limbs; and the detailed description of post-burn hypermetabolism as well as definition of effective techniques to provide total metabolic support to badly burned patients.

Thermal research developments directly attributable to the institute have decreased the mortality associated with 0 to 50 percent body surface burns to one-third that of 16 years ago and that associated with 50 to 60 percent to one-half that of 16 years ago.

In addition to the preceding contributions, the USAISR established trained flight teams to provide prompt aeromedical transfer of soldiers who receive thermal injuries. Such aeromedical transfer insures continuity of care along the evacuation route and by providing trained attendants, reduces inflight complications and increases survival significantly. During the past 15 years, these trained flight teams have made an average of eight flights per month.

In compliance with USAISR's mission to train physicians and ancillary medical personnel in the principles of management of thermally injured patients, the institute has current affiliation agreements for such educational activities with 52 medical schools and hospitals throughout the United States.

Army Aeromedical Research Laboratory

The U.S. Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL, was established in 1962. Its mission is medical research in support of the Army

aviation community and airborne activities, and maintenance of a central aeromedical research and reference library for the Army's large aviation effort. Starting with a modest budget of $229,562 and six military and three civilian employees, USAARL now has 141 permanent employees (51 percent military), and an FY 82 budget of over $5 million.

USAARL directs its efforts toward medical problems in the areas of acoustics, vision, crew workload and stress, vibration, impact, and life support systems.

In-flight and on-the-ground noise hazards abound. Turbine engines and gears produce high-frequency noise; rotor blades and vibration of tracked vehicles create low-frequency noise; and weapons produce impulse noise. Field and laboratory investigations seek to evaluate the effects of noise and its possible threat to hearing and disruption of communication, and ways to reduce the noise or to protect the exposed soldier. Helmets and hearing protective devices are also evaluated.

Contract and in-house projects are also keyed to studies of tolerance of impact force on the whole body, head and neck, and impact forces of projectiles, to find means to protect the soldier. Vibration research defines some of these effects and tries to determine a means to alleviate the detrimental influence of exposure to vibration of modern weapon systems.

Change in the aviation environment demands continual health hazard assessment of new or modified equipment and environmental conditions. Researchers are evaluating chemical-biological protective uniforms for aviators because the outfits developed for ground troops don't work well for air crews. Altitude chamber static and flight tests on a molecular sieve oxygen system are in progress to support crews in aircraft that no longer fly "low or slow."

Laboratory and field experiments strive to improve the efficiency of the eyes in interpreting information presented by helmet mounted displays, cathode ray tubes, and a variety of sophisticated vision enhancement techniques and by optical assessment of visors, spectacles and goggles.

USAARL seeks to determine the human ability to function when vision is degraded by hypoxia or exotic chemicals and to determine a person's visual ability to identify moving targets under adverse conditions.

With widespread use of chemical warfare agents, the survival of the unit as well as the individual may depend on visual acuity. USAARL is developing a comprehensive biomedical data base on the effects of selected nerve agents, candidate antidotes, possible prophylactic compounds, or combinations of the three on the retina and higher visual centers. Ultimately, methods will be developed to predict how well a soldier will be able to visually complete his mission following a specified exposure.

Army Medical Bioengineering R&D Laboratory

Broad mission responsibilities being met by a diversified, multidisciplinary team of scientists and engineers best describe the U.S. Army Medical Bioengineering R&D Laboratory (USAMBRDL), Fort Detrick, Frederick, MD. One of nine medical research laboratories under the USAMRDC, USAMBRDL is the only one active in all five of the parent command's broad missions.

Current emphasis is directed toward the Army's urgent need for field medical materiel for patient care on the chemical battlefield. The lab is also continuing its traditional role in developing field medical, dental, and vector control equipment, with preventive medicine and casualty care applicability.

A comprehensive program in the Environmental Protection Research Division is designed to provide the data base to enable the Army to establish standards for compliance with executive orders, The Clean Air Act, and The Water Quality Act, and to derive standards for cost-effective pollution abatement procedures at munition plants.

This environmental division's occupational health research group provides the research expertise to support weapons development activities. This is achieved by assuring that weapons safety and health hazards are addressed sufficiently early in the development process to provide cost-effective soldier-weapons system compatibility.

Some of the current field medical materiel R&D projects of the Applied Research Division include development of medical equipment to facilitate decontamination, and monitoring vital signs of patients during evacuation.

Other work involes fit, function and operability studies for medical equipment and plans for new chemical field shelters under DOD development.

Freedom from many of the constraints associated with film use in field X-ray applications is a primary goal of new technology being developed which will utilize nonfilm image detectors and television for diagnostic procedures. This capability will not only eliminate the need for film, but also will reduce patient radiation exposure, reduce equipment weight and size, and since the image is transmittable, provide a capability for consultation with specialists located at long distances.

A project designed to develop technology for field generation of pyrogen-free water for medical use has potential for elimination of most of the logistical burden associated with supplying sterile water needed for IV solutions and injections in field medical facilities.

Optimal responsiveness and flexibility are achieved through a prudent blend of in-house and extramural contract R&D. The FY 82 in-house budget of approximately $4.4 million is augmented by $7.2 million in funds available to support mission-essential extramural research contracts with industry, universities, non-DOD federal laboratories, and commercial research facilities. Reimbursable funds of about $600,000 are available to support specific research projects conducted for other governmental agencies.

Army Medical Research Institute of Chemical Defense

The nucleus of what is now the U.S. Army Medical Research Institute of Chemical Defense (USAMRICD) at Aberdeen Proving Ground, MD was formed in 1915 when the War Department gave responsibility for designing protective equipment against chemical agents to the Medical Department.

USAMRICD conducts research, development, test, and evaluation on medical defense against chemical warfare. This mission includes fundamental research or mechanisms of action of CW agents and antidotes.

The purpose of the research is to establish data from which to devise improved prevention and treatment of casualties; develop and evaluate drugs and other methods for the prevention, resuscitation, treatment and management of chemical casualties; and assist in the integration of products of these mission activities into the logistical system, doctrine development, and training; and the training of medical and non-medical personnel in management and prevention of chemical casualties.

USAMRICD has a professional staff of 80 scientists, of whom one-third are military. The majority of the professional staff have advanced degrees, which includes 23 doctorate, four medical and 11 veterinary medical degrees. The institute also has 132 technical personnel to support the professional staff.

The R&D efforts of USAMRICD are concentrated in the fields of neuropharmacology (vertebrate and invertebrate models), pharmacokinetics, neurotoxicity, cardiopulmonary physiology,

enzyme chemistry, clinical chemistry, membrane biochemistry, electron microscopy, immunobiology, and veterinary pathology.

Basic research studies are being conducted on mechanisms of anticholinesterases and antidotes, central and peripheral neurophysiological mechanisms of nerve agents, neurotransmitters, and receptors and immunological methods for determining agent distribution.

Applied research is directed towards the development of animal, non-animal and computer biomedical models; standardization of methods and procedures; biomedical data acquisition, analysis, prediction and information transfer; toxicological and behavioral effects of sublethal doses of CW agents, tolerance to chronic CW agent exposure; toxicological effects of chemotherapeutics; safety and efficacy of pretreatment compounds; sensory effects of CW agent; vesicant treatment technology; soldier and patient decontamination technology, and management and treatment of mass casualties.

Many of these research efforts are supported by an expanding R&D contract program and collaboration with USAMRDC sister institutes, other government laboratories, universities and research efforts with NATO countries.

Army Institute of Dental Research

Today the U.S. Army Institute of Dental Research (USAIDR) mission focuses exclusively on support of the soldier in combat. Emphasis continues and has increased on the development of new methods and materials for emergency surgical management of maxillofacial wounds on the battlefield and the definitive surgical restoration of the wounded soldier to full function.

This effort, which represents approximately 70 percent of USAIDR research, includes the development of biocompatible, biodegradable materials for use as implants to replace destroyed tissues; research to devise new and improved methods and materials for treating wound infections, and the development of more effective means of managing the wound healing process.

Studies are also being conducted on the effects of various types and sizes of missiles on the facial complex with the objectives of devising practical facial shielding for the soldier and developing the most effective strategies for managing the wide range of maxillofacial wounds that occur in combat.

Approximately 30 percent of the USAIDR R&D effort is directed toward combat dentistry. This includes the development of simplified and rapid methods for the prevention and treatment of field dental emergencies, dental materials which are storage-stable and effective under wide ranging climatic conditions, and lightweight, rugged, self-contained field dental equipment.

The USAIDR, located at WRAMC, Washington, DC, and Fort George G. Meade, Laurel, MD, has a professional staff of 25 scientists, most of whom are military dentists with advanced degrees and training relevant to the military. The staff also includes four civilians and one MSC scientist.

The institute's research in recent years has produced a number of experimental products which promise to significantly improve the treatment of combat maxillofacial wounds. This includes several polymeric and ceramic materials for the stabilization and replacement of damaged bone during healing. These materials are safely degraded by body processes as new repair bone take their place.

A polymer is also being used to encapsulate antibiotics in a controlled release system so that relatively small single-doses applied to wound surfaces can effectively fight wound infection for extended periods.

The USAIDR research effort is supported by an active and effective contract program conducted in universities, non-profit research institutes, R&D companies and other government labs.

Army Research Institute of Environmental Medicine

Physiologically and medically, the U.S. soldier, although perhaps in better physical condition, is little different from his civilian counterparts in his response to climatic extremes. The soldier during a military operation, however, cannot afford the luxury of coming in from the cold, getting out of the heat, or stopping whatever he is doing simply because he is uncomfortable or tired. The requirement to continue his mission, regardless of discomfort, makes the soldier different from others.

An important function of U.S. Army Research Institute of Environmental Medicine (USARIEM), is to advise military commands of biological responses which could limit military operations or pose a threat to the soldiers physical well-being, even though these responses are the body's way of warning and thereby protecting us from harm. The institute, a tenant activity on the grounds of the U.S. Army Natick Research and Development Laboratories, at Natick, MA, is derived from elements of the Environmental Protection Division of the U.S. Army Quartermaster Research and Engineering Command at Natick, MA, and the Army Medical Research Lab at Fort Knox, KY.

Initially comprised of 45 civilian and military scientists and technicians and located in temporary facilities provided by Natick, the institute presently has 162 personnel, and occupies a new building at the Natick installation.

The mission of USARIEM is to conduct basic and applied research to determine the effects of heat, cold, high terrestrial altitude, and work upon the soldier's life processes, performance and health. The goal is to understand the complex interaction of environmental stresses, the body's defense mechanisms, and the techniques, equipment and procedures best calculated to make the soldier operationally effective and provide environmental protection.

USARIEM also conducts research in the physiological aspects and health effects of Army physical fitness training. Additionally, USARIEM provides technical, advisory, and consultant services to Army commanders, installations and activities in support of the Army preventive medicine program.

Modern laboratories of USARIEM are equipped to support militarily relevant research in physiology, biochemistry, pharmacology, psychology, physical anthropology, histology, pathology, medicine, physics and veterinary medicine. Equipment is available for thin layer, gas and liquid chromatography, electron microscopy, automated analyses of almost any constituent in body fluids, scintillation counting for tracing distribution of important substances within tissues and cells, and separation and analytical ultracentrifugation.

Electronic instrumentation is capable of measuring such widely disparate functions as blood flow in minute vessels and evoked action potentials from the sensory cortex in response to visual stimuli. Computers are available for data storage and analysis.

Available to USARIEM investigators are many unique, highly specialized environmental chambers, capable of supporting human research in a wide variety of simulated environmental extremes. Fourteen environmental rooms are capable of providing controlled temperatures ranging from −40 to +140°F.

Two altitude chambers with an airlock can simulate altitudes up to 25,000 feet, controlled temperatures from −30 to 105°F, and changes in humidity from 20 to 80 percent. Both can be operated 24 hours a day for an indefinite number of days in succession.

Major research areas include military performance, human adaptations to

climate and related stresses, the biophysics of clothing and the pathophysiology of environmentally induced diseases, e.g., cold injury, acute mountain sickness and heat stroke.

Current research includes the use of human volunteers, goats, pigs and rats exposed to cold, heat or extreme altitude. By studying the behavioral patterns and the effects of environmental extremes upon them, it may be possible to predict and improve combat effectiveness under a wide variety of environmental and emotional stresses.

USARIEM is fortunate to have a staff that includes approximately 32 scientists at the doctoral level, and another 17 with masters degrees. Military personnel include 18 officers and 52 enlisted. Scientists and supporting technologists are grouped organizationally into seven divisions: Altitude, Exercise Physiology, Experimental Pathology, Health and Performance, Heat, Military Ergonomics and the Research Support Division.

In summary, the USAMRDC research and development program is designed to support the most valuable and vulnerable component of all battlefield systems, the "individual soldier." The Command's goal is to conduct research designed to keep the soldier healthy, but if that fails and he becomes sick or injured, then it is expected for the USAMRDC program to have developed the end products—techniques and material—to permit swift and effective treatment and rapid return to duty.

The preceding article was prepared by key personnel at the U.S. Army Medical R&D Command headquarters and laboratories.

Army Research Institute (ARI) Conducts 'People' Aspect of R&D

By ARI Commander COL L. Neale Cosby

Making the armed forces more effective at its job isn't simply a matter of building bigger and more effective weapons. That's one reason the Army employs 200 PhD research psychologists in the Army Research Institute (ARI) with headquartes in Alexandria, VA.

ARI research is concerned with the whole person functioning in the Army system. The understanding of human behavior—the continual subject of investigation by the Institute's staff—leads to a better matching of soldiers to Army jobs, improved equipment designed with the soldier in mind, and better trained soldiers and units. Stated summarily, the mission of ARI is to maximize combat effectiveness through research in the acquisition, training and utilization of soldiers in military systems.

ARI is the principal Army R&D agency conducting the "people" side of research and development. Because the soldier is the critical element in all aspects of military life, regardless of the degree to which hardware is included, the agency's research program is all-inclusive and multi-faceted. Research conducted by the Institute is concerned with the interaction of the soldier with the systems he must operate and maintain, as well as methods for assigning him to a job where he can be most productive and methods for training him to a level of combat readiness.

One of the largest groups of behavioral and social scientists in the United States, ARI is a field operating agency responsible to the Deputy Chief of Staff for Personnel (DCSPER). In addition to its principal installation in Alexandria, ARI has 10 field units—nine in the continental United States and one in Mannheim, Germany. Working with troops in the field not only permits its behavioral scientists to apply research results, but it also gives them a chance to learn first-hand the research needs of the Army.

Because the human component is the most complex, yet most flexible component in man-machine systems, behavioral research has increasingly addressed a wide range of issues presented by the Army of today and tomorrow. From a concentration on personnel measurement testing used throughout World War II, today finds research programs that are also concerned with identifying manpower and personnel requirements for new systems early in design, developing methods for using computer technology to shift the workload "from the head to the hardware", as well as new training techniques that exploit the potential of advanced information technology.

ARI's research program is concerned with enlisted men and officers throughout their careers as well as in all aspects of their job. Bringing the individual into the service is only the first step. His personal goals and his unit's goals must become almost synonymous. The individuality he brings to enlistment must be reconciled with a new focus on group accomplishment. There is a clear mandate to move the management/assignment/training/evaluation/operations from an individual basis to a collective or unit basis. Individuals do not fight wars. Units fight wars.

The soldier must be provided with the necessary knowledge and skills for surviving and winning in combat. Many soldiers entering the Army today do not possess the basic learning skills needed to receive maximum benefit from Army training. Hence the Army must provide initial instruction in basic learning and life-coping skills to allow these men and women to absorb the training that will make them productive and useful soldiers. The new soldier must be matched to the skills needed by the force, specifically the skills required by his MOS. Which tasks are to be allocated to the soldiers? Which to the hardware?

But as modern skill requirements proliferate, there is a decreasing availability of trainable recruits. The need for tailoring computer operation to skill levels is compounded when recruits with low skills in reading, oral English comprehension, and math with much shorter attention spans are accepted. ARI examines these two related problem areas as typical of their many program concerns. Solutions to the above problems lead to payoffs in terms of improved human performance when troops are committed to battle.

ARI's research products are developed to meet broad Army rather than local needs in the areas of manpower and personnel, training and systems. The following sampling of recent research products helps to characterize the results of the Institute's research program: a new basic M-16 rifle marksmanship training program, a flight aptitude selection test to improve the success rate in selecting and assigning aviators, human factors guidelines for the design of the man-computer interface in future computer-based systems, techniques for the management of tank crew turbulence, and a model for optimizing the mix of simulator and aircraft training time for rotory wing pilots.

Research requirements that lead to the development of products such as these are obtained from top Army leadership itself as well as from systematic surveys of all major commands. It is ARI's job to formulate research and development programs related to major "people" problems, then to carry out the necessary research and development, and finally to help the Army proponent to put the research product into practical use.

Challenges to be met by ARI require the cost-effective application of advanced technology to soldier-related problems, consideration of societal influences, current Army demands, and Army requirements for the battlefield of the future. In order to meet such challenges, ARI scientists communicate with and visit Army units world-wide, they communicate with other governmental agencies, foreign military and academic institutions, universities, non-profit organizations, and industry.

Success in meeting challenges for people-oriented research in January 1982 earned ARI, the Army's Laboratory "Award for Excellence."

DEPARTMENT OF DEFENSE

Washington, D.C.

GOALS AND OBJECTIVES
FOR
DEPARTMENT OF DEFENSE
RESEARCH AND DEVELOPMENT LABORATORIES

The Department of Defense laboratories exist to achieve—in cooperation with universities and industry —a level of technological leadership that will enable the United States to develop, acquire, and maintain military capabilities needed for national security.

MISSION

- Ensure the maintenance and improvement of national competence in technology areas essential to military needs.
- Avoid technological surprise and ensure technological innovation.
- Maintain a continuity of effort, free from excessive commercialization pressure, directed toward the conception and evolution of advanced military materiel and support technologies.
- Pursue technology initiatives through the planning, programming, and budgeting process; allocate work among private sector organizations and government elements.
- Act as principal agents in maintaining the technological base of the Department of Defense.
- Provide materiel acquisition and operating system support.
- Have available a fast-reaction capability to solve critical, immediate technical problems that arise when unexpected operational situations are encountered.
- Stimulate the use of demonstrations and prototypes to mature and exploit U.S. and allied technologies.
- Carry out activities having high technological risk or requiring intensive resource investment not available from the private sector.
- Interface with the worldwide scientific community; provide support to other governmental agencies.

OPERATIONS

- Respond to national defense needs by undertaking actions to
  - Achieve timely improvements in military systems and develop techniques for increasing their effectiveness
  - Reduce manpower and skill constraints on materiel performance
  - Lower materiel production, operation, and support costs
  - Extend life of operational systems
- Continue intensive user-developer interfacing to
  - Achieve greater sensitivity to potential combat requirements and operating environments
  - Integrate technological objectives with materiel readiness, modernization, and sustainability requirements
  - Evolve effective balance between technology push and requirements pull
- Continue a vigorous partnership with industry and the academic community.
- Distribute efforts appropriately across short-, mid-, and long-term horizons.
- Participate actively in the overall Defense planning process.

MANAGEMENT

- Provide laboratory managers with the responsibility, authority, and flexibility to manage laboratories and technical programs through use of broad guidelines and without overlapping controls.
- Ensure competency of Personnel
  - Recognize clearly that the most valuable resource of the laboratories is the capability, skill, and creativity of their personnel
  - Provide for personnel stability, challenging work, and meaningful incentives
  - Provide for equal opportunity for career development, training, promotion, recognition and reward
- Upgrade Facilities and Equipment
  - Remove limitations which constrain modernization of laboratories
  - Promote productivity, energy efficiency, and cost avoidance through policies which provide for modern facilities and equipment
  - Base replacement policies on practices that befit the business venture nature of research and development activities.
- Provide effective procedures for Procurement and Acquisition
  - Provide laboratories with the authority and capability to make procurements and acquisitions in a timely and efficient manner
  - Ensure technical excellence in contractor performance
- Achieve continuing Assessment and Accountability

The Office of the Secretary of Defense and the Military Departments are jointly responsible for establishing policies and procedures conducive to the continuing vitality of the laboratories. Accordingly, periodic evaluations will be conducted to assess the health of the laboratories, the quality and quantity of their contributions, and their performance against the public's legitimate expectations of efficient and effective use of personnel and financial resources.

DEPARTMENT OF THE ARMY

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